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KWIK: AN ALGORITHM FOR CALCULATING MUNITION EXPENDITURES FOR SM--ETC(U)
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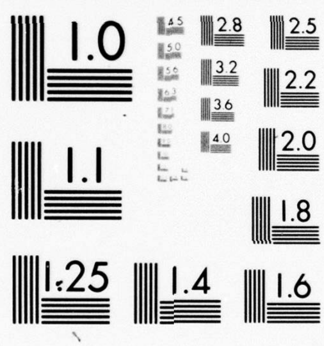

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KWIK: AN ALGORITHM FOR CALCULATING MUNITION EXPENDITURES FOR SMOKE SCREENING/OBSCURATION IN TACTICAL SITUATIONS

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AD A070958

APRIL 1979

by

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Ricardo Peña

Frank V. Hansen

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US Army Electronics Research and Development Command
Atmospheric Sciences Laboratory
White Sands Missile Range, NM 88002

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ASL-TR-0030	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER 9
4. TITLE (and Subtitle) 6 KWIK: AN ALGORITHM FOR CALCULATING MUNITION EXPENDITURES FOR SMOKE SCREENING/OBSCURATION IN TACTICAL SITUATIONS		5. TYPE OF REPORT & PERIOD COVERED R&D Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Robert K. Umstead, Ricardo Pena, Frank V. Hansen		8. CONTRACT OR GRANT NUMBER(s) 12 82p.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Atmospheric Sciences Laboratory, White Sands Missile Range, NM 88002		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA Task No. 1L1.62111AH71-26
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Electronics Research and Development Command, Adelphi, MD 20783		12. REPORT DATE 11 April 1979
		13. NUMBER OF PAGES 80
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 16 1L162111AH71 17 26		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

14 ERADCOM ASL-TR-0030

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Smoke screening
Obscuration
Turbulent diffusion
Munition expenditure
Atmospheric optics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

KWIK, an algorithm for calculating munition expenditures for smoke screening/obscuration in tactical situations, is described. Nine basic meteorological inputs plus fundamental definitions of meteorological optics and Gaussian diffusion theory are utilized in the approach. A flowchart of the algorithm is also given with the software program listing in FORTRAN, BASIC, and HPL programming languages.

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CONTENTS

INTRODUCTION

The purpose of smoke screening/obscuration with chemical smokes such as white phosphorus (WP) or hexachloroethane (HC) in a tactical environment is to attenuate the transmission of electromagnetic radiation in a finite optical path or line of sight to a threshold level of the human eye or electro-optical sighting, designating, or guidance system. Attenuation of electromagnetic radiation is dependent upon such factors as absorption and scattering ~~by aerosols and precip~~itation and the crosswind integrated concentration of the plume or puff of smoke deliberately injected into the line of sight. The amount of chemically produced smoke (munition expenditures) required can be determined from empirically derived relationships of transmittance versus concentration data.

Current techniques for calculating munition expenditures do not consider certain meteorological parameters such as visibility and relative humidity. Ignoring such parameters can result in the incorrect calculation of required smoke munitions. Consequently, a semiempirical algorithm has been developed for battlefield use for calculating munition expenditures.

The algorithm is called KWIK (an acronym for crosswind integrated concentration). The primary output is munition expenditures for artillery engaged in smoke screening/obscuration support of other military elements. This report describes the meteorological and mathematical background of KWIK.

Figure 1 shows a typical scenario where smoke screening is utilized to conceal the movement of friendly forces along path X. The enemy is believed to be somewhere on a hill having a line of sight L. The symbols used on the figure are described as follows:

N - grid north

S - angle of line of sight to target

L - slant range to target

X - distance to be smoked

Z - mean height of target

H - release height of smoke

V - wind direction

α - direction of line of sight from grid north

A - angle between wind direction and line of sight: $|V - \alpha|$

A block diagram is presented in figure 2 which contains details of the four main sections of the KWIK smoke program: (1) meteorological inputs

and calculations, (2) meteorological optics and smoke concentration calculations, (3) atmospheric diffusion and smoke source strength calculations, and (4) munition expenditures. A description of the algorithm is presented to show mathematically how the four parts of the algorithm are derived. The fifteen tables contain equations and values of coefficients which are essential to the appropriate calculations in the algorithm. A flowchart of the algorithm is also given followed by glossary of mnemonics and software listings using FORTRAN, BASIC, AND HPL programming languages. The latter is for use with the Hewlett-Packard model 9825A desktop computer.

DESCRIPTION OF ALGORITHM

Meteorological Inputs and Calculations

Nine meteorological inputs are necessary to execute the algorithm. The inputs are:

1. Cloud ceiling (hundreds of feet)
2. Cloud cover (percent)
3. Visibility (miles)
4. Precipitation indicator (yes or no)
5. Temperature (degrees F)
6. Dewpoint (degrees F)
7. Wind direction (tens of degrees)
8. Windspeed (knots)
9. Length of average surface roughness element (centimeters)

Met information of this type is available in the battlefield from one of the following sources:

1. US Army observation
2. US Air Force Air Weather Service (USAF-AWS) airfield observations
3. AF-AWS-GWC (Global Weather Central) prognostications

In addition, the following information about the location requiring the smoke is also an input:

1. Site identification (if any)
2. Latitude of site (decimal degrees)

3. Longitude of site (decimal degrees)

4. Altitude of site (kilometers)

5. Julian data and Zulu hour of met data recording

6. Slant range to target (meters)

7. Angle of sight to target (decimal degrees)

8. Total distance to be smoked (meters)

9. Release height of smoke (meters)

10. Mean height of target (meters)

11. Direction of line of sight (decimal degrees)

12. Time smoke is required (minutes)

The input units are shown both in the English and metric systems because that is the form in which they are supplied by the sources quoted. However, the program converts all units to the metric system.

The calculation of atmospheric stability is based upon work by Dr. F. Pasquill.[1] Stability close to the ground is dependent mainly upon net radiation and windspeed. Incoming radiation is dependent upon solar altitude, which is a function of time of day and season of the year. The amount of cloud cover and its thickness will also influence incoming or outgoing radiation. For daytime, table 1 is used to arrive at an insolation class number as a function of solar altitude. This number becomes the net radiation index (table 2) after being modified by the amount of cloud cover and ceiling. For instance, if the total cloud cover is 100 percent and the ceiling is less than 7000 feet (whether day or night), the net radiation index is equal to 0. For nightime, estimates of outgoing radiation are made by considering the amount of cloud cover. For example, if the total cloud cover is less than or equal to 40 percent, -2 will be used for the net radiation index; if it is greater than 40 percent, the net radiation index will be -1. Table 2 shows the stability class as a function of windspeed and radiation index. The stability classes are identified as follows:

A - extremely unstable

B - unstable

C - slightly unstable

[1]F. Pasquill, 1961, "The Estimation of the Dispersion of Windborne Material," Meteorol Mag, Vol 90

D - neutral

E - slightly stable

F - stable

G - extremely stable

These are also identified, for computation purposes, as numbers 1 through 7. The net radiation index ranges from 4, the highest positive net radiation directed toward the ground, to -2, the highest negative net radiation directed away from the earth. Instability occurs when the positive net radiation is high and winds are light and during neutral conditions with cloudy skies or high windspeeds. The algorithm utilized this procedure to determine the atmospheric stability category.

The algorithm converts visibility from miles to kilometers and temperature and dewpoint from degrees Fahrenheit to degrees Celcius. Relative humidity, a function of temperature and dewpoint, is calculated as a ratio of the vapor pressure (P_v) at a temperature T (degrees C) and the saturation vapor pressure (P_{vm}) at dewpoint T_d (degrees C) expressed by:

$$RH = \frac{P_v}{P_{vm}} (100) , \qquad (1)$$

where

$$P_{vm} = 6.11(10)^{aT_d/T_d + b} .$$

The constants a and b are as follows:

<u>over ice</u>	<u>over water</u>
a = 9.5	a = 7.5
b = 265.5	b = 237.3

The above solution, according to Haurwitz[2] can be attributed to Tetons and is similar to a theoretical formula derived from the equation of Clausius

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[2]B. Haurwitz, 1941, <u>Dynamic Meteorology</u>, McGraw-Hill Book Company, Inc., New York

Clapeyron described by Brunt.[3] The only condition necessary to apply the above is the ability to distinguish between the saturation pressure over ice and over water, i.e., the freezing point.

Meteorological Optics and Smoke Concentration Calculations

The optics portion of KWIK is adapted from an approach to atmospheric transmission suggested by Downs.[4] Transmittance of light at various wavelengths through a path is determined by calculating the attenuation due to absorption by water vapor, scattering by haze or fog, and precipitation. When the attenuation due to atmospheric conditions is known, the attenuation due to smoke that is required to lower transmittance to a threshold contrast for a particular wavelength can be computed. By use of the transmittance and empirically derived relationships between transmittance and concentration for various smokes, the crosswind integrated concentration for a particular smoke can then be computed.

Absorption is directly attributable to the amount of precipitable water in a path, assuming the water vapor concentration in the atmosphere is reasonably well behaved and exhibits a scale height of about 2 km. The water vapor concentration expressed in centimeters per kilometer of path length may then be given as:

$$W = W_o e^{-(L \sin \theta)/2} , \qquad (2)$$

where W_o is the precipitable water along a path L and θ is the angle between the horizontal and the height of a target above or below an observer. W_o is computed from the following linear regression equation relating precipitable water and dewpoint temperature (T_d):

$$W_o = 0.4477 + 0.0328T_d + 1.2(10)^{-3}T_d^2 + 1.84(10)^{-5}T_d^3 \qquad (3)$$

Equation (3) was fit to data extracted from Downs[4] (figure 4 in Downs) and is considered valid for all geographical regions.

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[3]D. Brunt, 1952, Physical and Dynamical Meteorology, second edition, Cambridge University Press, London

[4]A. R. Downs, 1976, "A Review of Atmospheric Transmission Information in the Optical and Microwave Spectral Regions," Ballistics Research Laboratories Report 2710

The amount of water vapor in the path, W, is given by:

$$W = W_o \int_0^L e^{-(L \sin \theta)/2} \, dL \, . \quad (4)$$

Transmission through the absorbing component of the atmosphere is calculated by using an error function absorption law developed by Elsasser[5]

$$T = 1 - \text{erf}\,(z) \, , \quad (5)$$

$$\text{erf}\,(z) = \frac{2}{\sqrt{\pi}} \int_0^z e^{-z^2} \, dz \, , \quad (6)$$

where

$$z = 0.5 \, \beta \sqrt{\pi W}$$

β = error function absorption coefficient as a function of wavelength (table 3).

Downs[4] states that the Elsasser approach is unable to correctly address long wavelengths and suggests using an approach described by Fisher[6] for the far infrared wavelengths (8μm-14μm). Thus the computation of transmission due to absorption by water vapor for the long wavelength case is given by:

$$T = e^{-0.0681W} \, . \quad (7)$$

Reduction in transmittance due to attenuation by haze and fog can be calculated by using the Mie theory. Downs[4] indicates that the Mie scattering coefficient decreases with altitude such that its behavior

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[5]W. M. Elsasser, 1942, "Heat Transfer by Infrared Radiation in the Atmosphere," Harvard Meteorological Series 6, Harvard University Press, Cambridge, MA

[4]A. R. Downs, 1976, "A Review of Atmospheric Transmission Information in the Optical and Microwave Spectral Regions," Ballistics Research Laboratories Report 2710

[6]D. F. Fisher et al., 1963, "Transmissometry and Atmospheric Transmission Studies Final Report," University of Michigan, Institute of Science and Technology

can only be estimated. Thus the following expressions for σ_M (Mie scattering coefficient) are, at best, an approximation to the behavior of the σ_M versus altitude relationship

$$\sigma_M = \sigma_{hf} e^{-L \sin \theta / 4.1} \quad V \geq G(\lambda) \,, \tag{8}$$

$$\sigma_{M_1} = \sigma_{hf} e^{L \sin \theta \ln (0.1/\sigma_{hf})} \quad V < G(\lambda),\ 0 < L \sin \theta \leq 1 \text{ km}$$

$$\sigma_{M_2} = 0.128 e^{-L \sin \theta / 4.1} \quad V < G(\lambda),\ 1 \text{ km} \leq L \sin \theta < \infty$$

$$\sigma_M = \sigma_{M_1} * \sigma_{M_2} \,, \tag{9}$$

where σ_{hf} is a coefficient of attenuation determined from a linear regression equation as a function of visibility and wavelength (table 4), based upon Downs'[4] evaluation of the best available data. V is visibility, and $G(\lambda)$ is the scale height of σ_M. $G(\lambda)$ is not constant; rather it is a function of altitude, visibility, and wavelength. Table 5 indicates approximations for $G(\lambda)$ for various wavelengths considered. Transmission along a path with attenuation σ_M can be determined by the equation

$$T = e^{-\int_0^L \sigma_M(L)\, dL} \,. \tag{10}$$

Thus, reduction in transmittance due to attenuation by haze and fog can be calculated by using equation (10) by substituting a value for σ_M according to equations (8) and (9). If precipitation is indicated (by input parameter), then the value for transmittance in equation (10) is set to one and a calculation is made for attenuation by precipitation instead.

[4]A. R. Downs, 1976, "A Review of Atmospheric Transmission Information in the Optical and Microwave Spectral Regions," Ballistics Research Laboratories Report 2710

The reduction in transmittance due to attenuation by precipitation can be obtained from the equation

$$T = e^{-\int_0^L \sigma_r(L)\, dL} , \tag{11}$$

where L is the path length and σ_r is an attenuation coefficient determined from a linear regression equation as a function of visibility and wavelength (table 6).

The total transmittance along an optical path is the product of the partial transmittance

$$T_{total} = T_a T_{hf} T_p T_s , \tag{12}$$

where

T_a = Transmittance due to attenuation by atmospheric absorption

T_{hf} = Transmittance due to attenuation by haze and fog

T_p = Transmittance due to attenuation by precipitation

T_s = Transmittance due to attenuation by smoke

T_s can then be calculated from equation (12), and the desired threshhold contrast of transmittance for a particular wavelength can be expressed by using the following equation:

$$T_s = \frac{T_{tc}}{T_a T_{hf} T_p} , \tag{13}$$

where T_{tc}, the threshold contrast, is based upon the Koschmieder[7] theory and is set equal to 0.02.

After the transmittance due to attenuation by smoke has been computed, the line of sight integrated concentration (CL) necessary to achieve this value can be calculated from a linear regression equation as a function of transmittance and wavelength (table 7). The data used to fit the regression equations comes from laboratory and atmospheric test results for transmittance through variable concentrations of different smokes over finite path lengths. The line of sight concentrations may now be utilized in a Gaussian diffusion scheme to determine smoke source strengths.

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[7]H. Koschmieder, 1924, "Theorie der Horizontalen Sichtweite," Beitr Phys Frein Atmos, 12:33-53, 171-181

Batchelor[8] pointed out that the Gaussian function could provide a general description of average diffusion in a continuous plume. Diffusion studies by Hay and Pasquill;[9] Cramer, Record, and Vaughan;[10] and Barad and Haugen[11] suggested that Gaussian plume formulae are quite practical and applicable in the atmosphere.

Atmospheric Diffusion and Smoke Source Strength Calculations

Successful smoke screening/obscuration in the surface boundary layer is largely dependent upon the existence of the meteorological data necessary to describe the diffusion process. Generally, because of the type of meteorological observations available in a battlefield environment, an assumption of Gaussian diffusion may be the only model for which adequate data will exist. Since KWIK was developed for actual field use, Gaussian diffusion theory was employed. Estimates of downwind dispersion may be derived by using methodology developed by various individuals, including F. Pasquill, F. A. Gifford, F. B. Smith, D. B. Turner, and R. P. Hosker, Jr.

The vertical dispersion coefficient, σ_z, is calculated from the following equation:

$$\sigma_z = F(z_o;\, X)\, g(X) \tag{14}$$

$$F(z_o;\, X) = \begin{cases} \ln\left\{c_1 X^{d_1}\left[1 + (c_2 X^{d_2})^{-1}\right]\right\}, & z_o > 10 \text{ cm} \\ \ln\left\{c_1 X^{d_1}\left[(1 + c_2 X^{d_2})^{-1}\right]\right\}, & z_o \leq 10 \text{ cm} \end{cases}$$

and

$$g(X) = (a_1 X^{b_1})/(1 + a_2 X^{b_2}) ,$$

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[8] G. K. Batchelor, 1949, "Diffusion in a Field of Homogeneous Turbulence, I. Eulerian Analysis," Australian J Sci Res, 2:437-450

[9] J. S. Hay and F. Pasquill, 1957, "Diffusion from a Fixed Source at a Height of a Few Hundred Feet in the Atmosphere," J Fluid Mech, 2:299

[10] H. E. Cramer, F. A. Record, and H. C. Vaughan, 1958, The Study of the Diffusion of Gases or Aerosols in the Lower Atmosphere. Report AFCRC-TR-58-239, Department of Meteorology, Massachusetts Institute of Technology

[11] M. L. Barad and D. A. Haugen, 1959, "A Preliminary Evaluation of Sutton's Hypothesis for Diffusion from a Continuous Point Source," J Meteorol, 16:12

where

The coefficients a_1, b_1, a_2, b_2 are given in table 8,

the coefficients c_1, d_1, c_2, d_2 are given in table 9,

and

X is total distance to be smoked (meters).

z_o is the surface roughness length computed by using the average roughness element (Y - one of the program inputs) and the following equation:

$$\log_{10} z_o = -1.24 + 1.19 \log_{10} Y \tag{15}$$

where Y is estimated by a visual survey of the average height of trees, bushes, or grass.

The lateral dispersion coefficient, σ_y, is calculated from the following equation:

$$\sigma_y(X) = a X^b \tag{16}$$

where X is the total distance to be smoked, a is obtained from table 10 as a function of stability category, and b is a constant equal to 9.0.

The previous calculations of σ_z and σ_y are for a continuous source, such as HC smoke. For a quasi-instantaneous source, such as WP, σ_z and σ_y are computed as two-thirds of the values determined in the continuous case, based on experimental results of Smith and Hay.[12]

The crosswind integrated concentration, CWIC, is determined from the computed line of sight integrated concentration value by applying a wind direction correction factor, f, as follows:

$$\text{CWIC} = (\text{CL})f \ , \tag{17}$$

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[12]F. B. Smith and J. S. Hay, 1961, "The Expansion of Clusters of Particles in the Atmosphere," Quart J Roy Meteorol Soc, 87:82

where

$f = \sqrt{3.3124/[6.76\ (\sin A)^2 + 0.49\ (\cos A)^2]}$

CL = line of sight integrated concentration

$A = |d_1 - d_2|$

d_1 = surface wind direction

d_2 = direction of line of sight

After the dispersion coefficients and the crosswind integrated concentration have been determined, source strength, Q, can be computed from the following equations:

Continuous Source

$$Q = X(\sigma_z V \pi^{\frac{1}{2}}) / \left(2^{\frac{1}{2}} e^{-0.5((Z-H)/\sigma_z)^2}\right) \quad (18)$$

Quasi-Instantaneous Source

$$Q = X(\sigma_z \sigma_y \pi)/e^{-(Z^2-H^2)/Z\sigma_z^2} , \quad (19)$$

where

σ_z = vertical dispersion coefficient

σ_y = lateral dispersion coefficient

H = release height of smoke source (meters) (figure 1)

Z = mean height of target (meters)

V = surface windspeed (mps)

Chemical smoke aerosols are hygroscopic and thus the source strength must be modified by a yield factor, which is a function of relative humidity, as follows:

$$Q_m = Q/Y , \quad (20)$$

where Y is the yield factor (table 11), and Q_m is the modified source strength.

Munition Expenditures

KWIK calculates munition expenditures following the procedure described in Army Training Circular 6-20-5.[13] Basically, this procedure determines the number of guns and the number of munitions per gun in order to calculate the total number of munitions needed for a smoke mission.

The number of guns is determined by the following equation:

$$G = Q_m/S \ , \tag{21}$$

where

G = number of guns

S = unit source strength (i.e., total amount of chemical material available in one munition)

The number of guns calculated is always rounded up to the nearest whole number.

Next, the total time for replenishment (i.e., the total time smoke replenishment is required to maintain the desired screen) is obtained from the relation:

$$W = T + A - B \tag{22}$$

where

W = time for replenishment

T = total time smoke is needed

A = time required for buildup (table 13)

B = munition burn time (table 14)

Since time for replenishment has been calculated, the number of munitions required for one gun can be computed as follows:

$$F = 1 + WD \tag{23}$$

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[13]"Field Artillery Smoke," 1975, Training Circular 6-20-5, US Army Field Artillery School, Fort Sill, OK

where

F = number of munitions for one gun

W = computed time for replenishment

D = rate of fire of gun (table 15)

The constant (1) in equation (23) represents the initial munition round fired by a gun.

Total munitions required, R, can now be calculated by the following equation:

$$R = GF \tag{24}$$

where

G is the number of guns, and F is the number of munitions per gun.

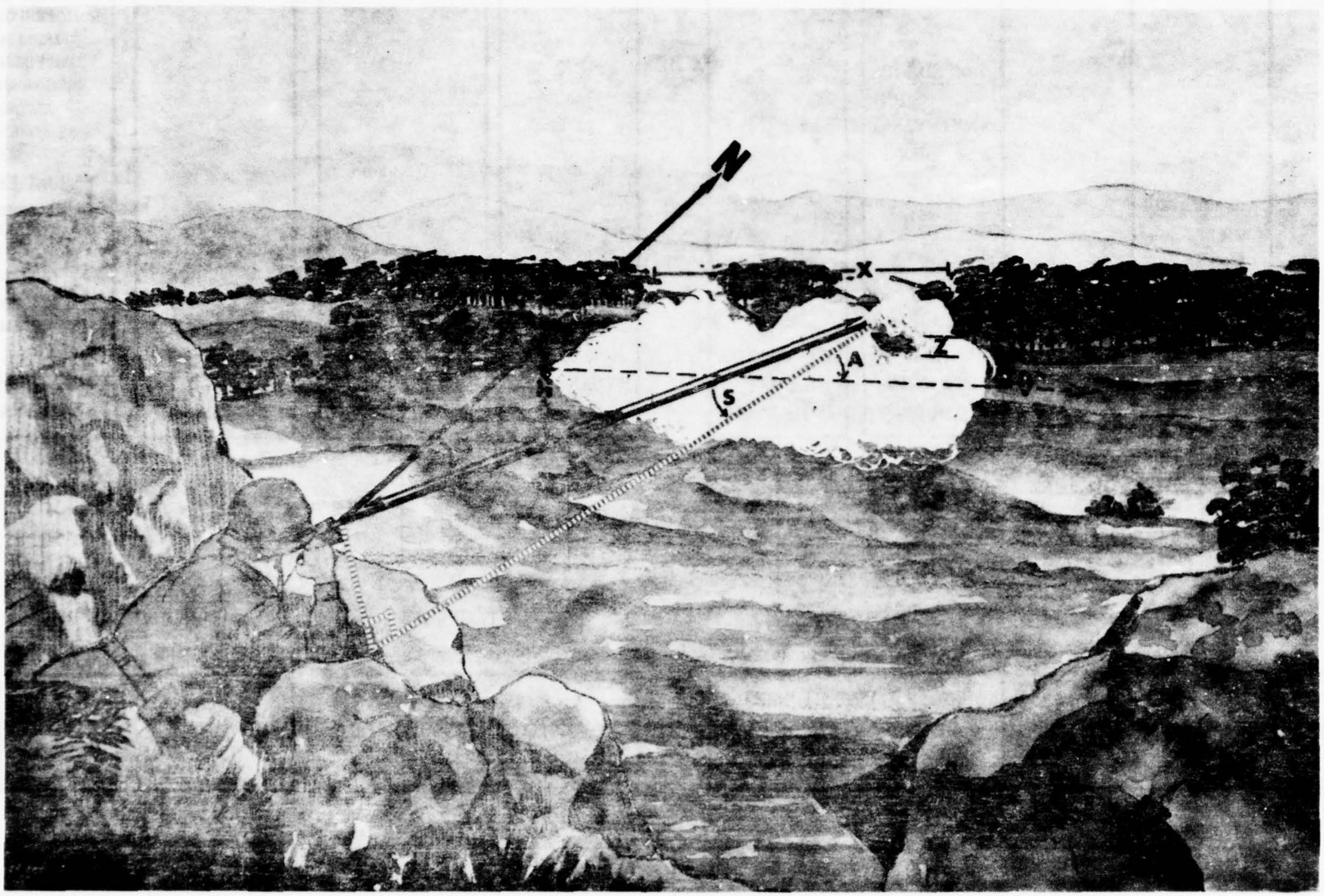


Figure 1. Smoke screening scenario.

Figure 2.

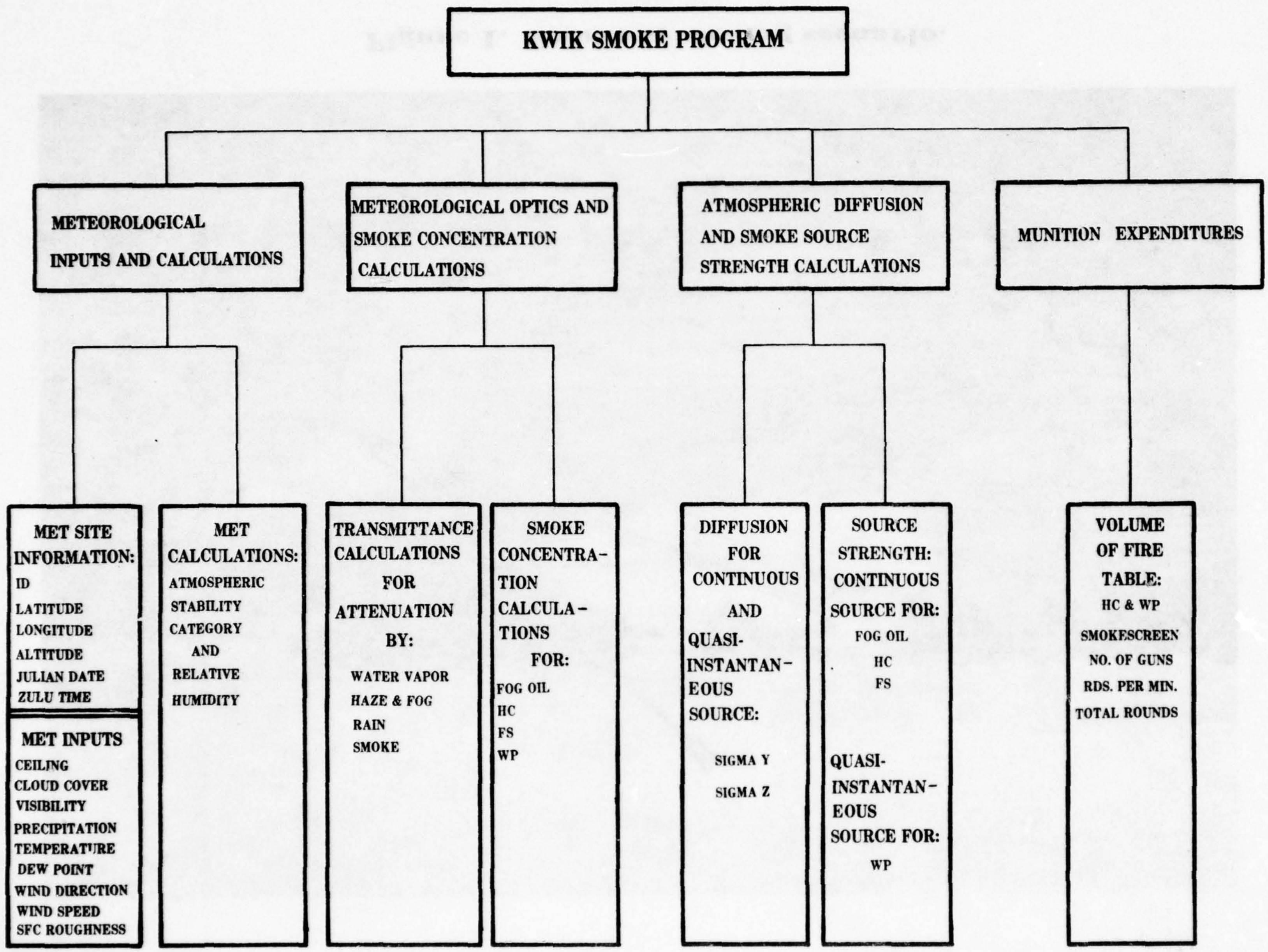

KWIK SMOKE PROGRAM
METEOROLOGICAL INPUTS AND CALCULATIONS
METEOROLOGICAL OPTICS AND SMOKE CONCENTRATION CALCULATIONS
ATMOSPHERIC DIFFUSION AND SMOKE SOURCE STRENGTH CALCULATIONS
MUNITION EXPENDITURES
MET SITE INFORMATION:
ID
LATITUDE
LONGITUDE
ALTITUDE
JULIAN DATE
ZULU TIME
MET INPUTS
CEILING
CLOUD COVER
VISIBILITY
PRECIPITATION
TEMPERATURE
DEW POINT
WIND DIRECTION
WIND SPEED
SFC ROUGHNESS
MET CALCULATIONS:
ATMOSPHERIC
STABILITY
CATEGORY
AND
RELATIVE
HUMIDITY
TRANSMITTANCE CALCULATIONS FOR ATTENUATION BY:
WATER VAPOR
HAZE & FOG
RAIN
SMOKE
SMOKE CONCENTRA- TION CALCULA- TIONS FOR:
FOG OIL
HC
FS
WP
DIFFUSION FOR CONTINUOUS AND QUASI- INSTANTAN- EOUS SOURCE:
SIGMA Y
SIGMA Z
SOURCE STRENGTH: CONTINUOUS SOURCE FOR:
FOG OIL
HC
FS
QUASI- INSTANTAN- EOUS SOURCE FOR:
WP
VOLUME OF FIRE TABLE:
HC & WP
SMOKESCREEN
NO. OF GUNS
RDS. PER MIN.
TOTAL ROUNDS

TABLE 1. INSOLATION AS A FUNCTION OF SOLAR ALTITUDE

Solar Altitude α	Insolation	Insolation Class No.
$60° < \alpha$	Strong	4
$35° < \alpha \leq 60°$	Moderate	3
$15° < \alpha \leq 35°$	Slight	2
$\alpha \leq 15°$	Weak	1

TABLE 2. STABILITY CLASS AS A FUNCTION OF NET RADIATION AND WINDSPEED

Windspeed (knots)	Net Radiation Index						
	4	3	2	1	0	-1	-2
0, 1	A	A	B	C	D	F	G
2, 3	A	B	B	C	D	F	G
4, 5	A	B	C	D	D	E	F
6	B	B	C	D	D	E	F
7	B	B	C	D	D	D	E
8, 9	B	C	C	D	D	D	E
10	C	C	D	D	D	D	E
11	C	C	D	D	D	D	D
≥ 12	C	D	D	D	D	D	D

TABLE 3. ERROR FUNCTION ABSORPTION COEFFICIENTS

Wavelength	β
Visual	0.118
1.06μm	0.22
2.3μm	0.14
3.8μm	0.55

TABLE 4. HAZE AND FOG ATTENUATION COEFFICIENT EQUATIONS

Visual $\ln \sigma_{hf} = 1.5551 - 0.9811 \ln V - 0.0197 (\ln V)^2 + 0.0041 (\ln V)^3$

1.06μm $\ln \sigma_{hf} = 1.5551 - 0.9811 \ln V - 0.0197 (\ln V)^2 + 0.0041 (\ln V)^3$

2.3μm $\ln \sigma_{hf} = 1.4491 - 1.0044 \ln V - 0.12(\ln V)^2 + 0.0032 (\ln V)^3$

3.8μm $\ln \sigma_{hf} = 1.2394 - 1.0436 \ln V + 0.0099 (\ln V)^2 - 0.0016 (\ln V)^3$

1.06μm $\ln \sigma_{hf} = 1.5176 - 1.7147 \ln V + 0.001 (\ln V)^2 + 0.0428 (\ln V)^3$

σ_{hf} = Haze and fog attenuation coefficient

V = Visibility (km)

TABLE 5. G(λ) - APPROXIMATIONS FOR SCALE HEIGHT OF HAZE AND FOG ATTENUATION COEFFICIENTS AS A FUNCTION OF WAVELENGTH

Wavelength	G(λ)
Visual	26.7
1.06μm	13.0
2.3μm	5.3
3.8μm	5.1
10.6μm	5.0

TABLE 6. RAIN ATTENUATION COEFFICIENT EQUATIONS

Visual $\ln - \sigma_r = 1.3306 - 0.6825 \ln V - 0.0753 (\ln V)^2 + 0.0129 (\ln V)^3$

1.06μm $\ln - \sigma_r = 1.4098 - 0.9865 \ln V - 0.0140 (\ln V)^2 + 0.0023 (\ln V)^3$

2.3μm $\ln - \sigma_r = 1.5497 - 0.8696 \ln V - 0.1084 (\ln V)^2 + 0.0231 (\ln V)^3$

3.8μm $\ln - \sigma_r = 1.5556 - 0.9013 \ln V - 0.0773 (\ln V)^2 + 0.0173 (\ln V)^3$

10.6μm $\ln - \sigma_r = 1.5928 - 0.9396 \ln V - 0.0627 (\ln V)^2 + 0.0168 (\ln V)^3$

σ_r = Rain attenuation coefficient

V = Visibility (km)

TABLE 7. EQUATIONS FOR DETERMINING LINE OF SIGHT INTEGRATED CONCENTRATION (CL) AS A FUNCTION OF TRANSMITTANCE (T) AND TYPE OF CHEMICAL SMOKE

	Visual
Fog oil	$CL = 0.0093 - 0.3428 \ln T - 0.0009 (\ln T)^2$
HC	$CL = 0.0119 - 0.2747 \ln T - 0.0013 (\ln T)^2$
FS	$CL = 0.0142 - 0.111 \ln T + 0.00004 (\ln T)^2$
WP	$CL = 0.0055 - 0.1541 \ln T - 0.0004 (\ln T)^2$

TABLE 8. COEFFICIENTS OF THE FUNCTION g(X) USED IN CALCULATING THE VERTICAL DISPERSION COEFFICIENT $\sigma_z(X)$ FOR THE VARIOUS STABILITY CATEGORIES (X IS GIVEN IN METERS)

Stability Category	a_1	b_1	a_2	b_2
A	0.112	1.06	5.38 (10^{-4})	0.815
B	0.130	0.950	6.52 (10^{-4})	0.750
C	0.112	0.920	9.05 (10^{-4})	0.718
D	0.098	0.889	1.35 (10^{-3})	0.688
E	0.0609	0.895	1.96 (10^{-3})	0.684
F	0.0638	0.783	1.36 (10^{-3})	0.672

TABLE 9. EQUATIONS USED TO COMPUTE THE ROUGHNESS CORRECTION FACTOR $F(z; X)$ USED IN CALCULATING $\sigma_z(X)$ [z_o IS ROUGHNESS ELEMENT LENGTH (cm)]

$$\ln c_1 = 0.444685869 + 0.294049265\ (\ln z_o) - 0.2\text{[illegible]}7213914\ (\ln z_o)^2$$
$$+ 0.155349504\ (\ln z_o)^3 - 0.032015723\ (\ln z_o)^4$$
$$+ 2.15168\ (10^{-3})\ (\ln z_o)^5$$

$$\ln d_1 = -1.298283909 - 1.006186784\ (\ln z_o) + 1.485094886\ (\ln z_o)^2$$
$$- 0.774136725\ (\ln z_o)^3 + 0.156559355\ (\ln z_o)^4$$
$$- 0.010823351\ (\ln z_o)^5$$

If $z_o < 10$, then

$$\ln c_2 = 5.77267\ (10^{-4}) + 2.31943\ (10^{-5})\ (\ln z_o) + 3.71041\ (10^{-5})\ (\ln z_o)^2$$
$$- 8.40602\ (10^{-6})\ (\ln z_o)^3 + 1.3421\ (10^{-7})\ (\ln z_o)^4$$
$$+ 2.55131\ (10^{-8})\ (\ln z_o)^5$$

If $10 \leq z_o \leq 40$, then

$$\ln c_2 = -11.56134901 = 2.148242814\ (\ln z_o) - 0.156210817\ (\ln z_o)^2$$
$$+ 7.03582\ (10^{-3})\ (\ln z_o)^3 - 1.47353\ (10^{-4})\ (\ln z_o)^4$$
$$+ 1.18256\ (10^{-6})\ (\ln z_o)^5$$

If $z_o > 40$, then

$$\ln c_2 = 1108.366588 - 103.5495836\ (\ln z_o) + 2.424499256\ (\ln z_o)^2$$
$$- 0.014584773\ (\ln z_o)^3 + 4.34517\ (10^{-5})\ (\ln z_o)^4$$
$$- 4.69556\ (10^{-8})\ (\ln z_o)^5$$

$$\ln d_2 = 0.500775609 + 1.092615788\ (\ln z_o) - 1.573065836\ (\ln z_o)^2$$
$$+ 0.724276579\ (\ln z_o)^3 - 0.140820904\ (\ln z_o)^4$$
$$+ 9.61621\ (10^{-3})\ (\ln z_o)^5$$

TABLE 10. COEFFICIENT USED IN CALCULATING THE LATERAL DISPERSION COEFFICIENT $\sigma_y(X)$ FOR THE VARIOUS STABILITY CATEGORIES (X IS GIVEN IN METERS)

Stability Category	a
A	0.22
B	0.16
C	0.11
D	0.08
E	0.06
F	0.04

TABLE 11. EQUATIONS USED TO CALCULATE CHEMICAL SMOKE YIELD FACTOR (Y) AS A FUNCTION OF RELATIVE HUMIDITY (RH)

For HC Smoke:

$$Y = 0.9337 + 0.0369\ RH - 7.0\ (10^{-4})\ RH^2 + 6.11\ (10^{-6})\ RH^3$$

For FS Smoke:

$$Y = 1.3775 + 0.09868\ RH - 1.8\ (10^{-3})\ RH^2 + 1.56\ (10^{-5})\ RH^3$$

For Fog Oil:

$$Y = 1$$

For WP Smoke:

$$Y = 3.2469 + 0.0774\ RH - 1.6\ (10^{-3})\ RH^2 + 1.73\ (10^{-5})\ RH^3$$

TABLE 12. UNIT (PER GUN) SOURCE STRENGTHS (GRAMS)

Gun	105 Howitzer		155 Howitzer	
Munition	HC	WP	HC	WP
Source Strength	18.9	1737.3	48.8	7076.2

TABLE 13. SMOKE BUILDUP TIME (MIN)

Gun	105 Howitzer	or	155 Howitzer
Munition	HC		WP
Buildup Time	1.0		0.5

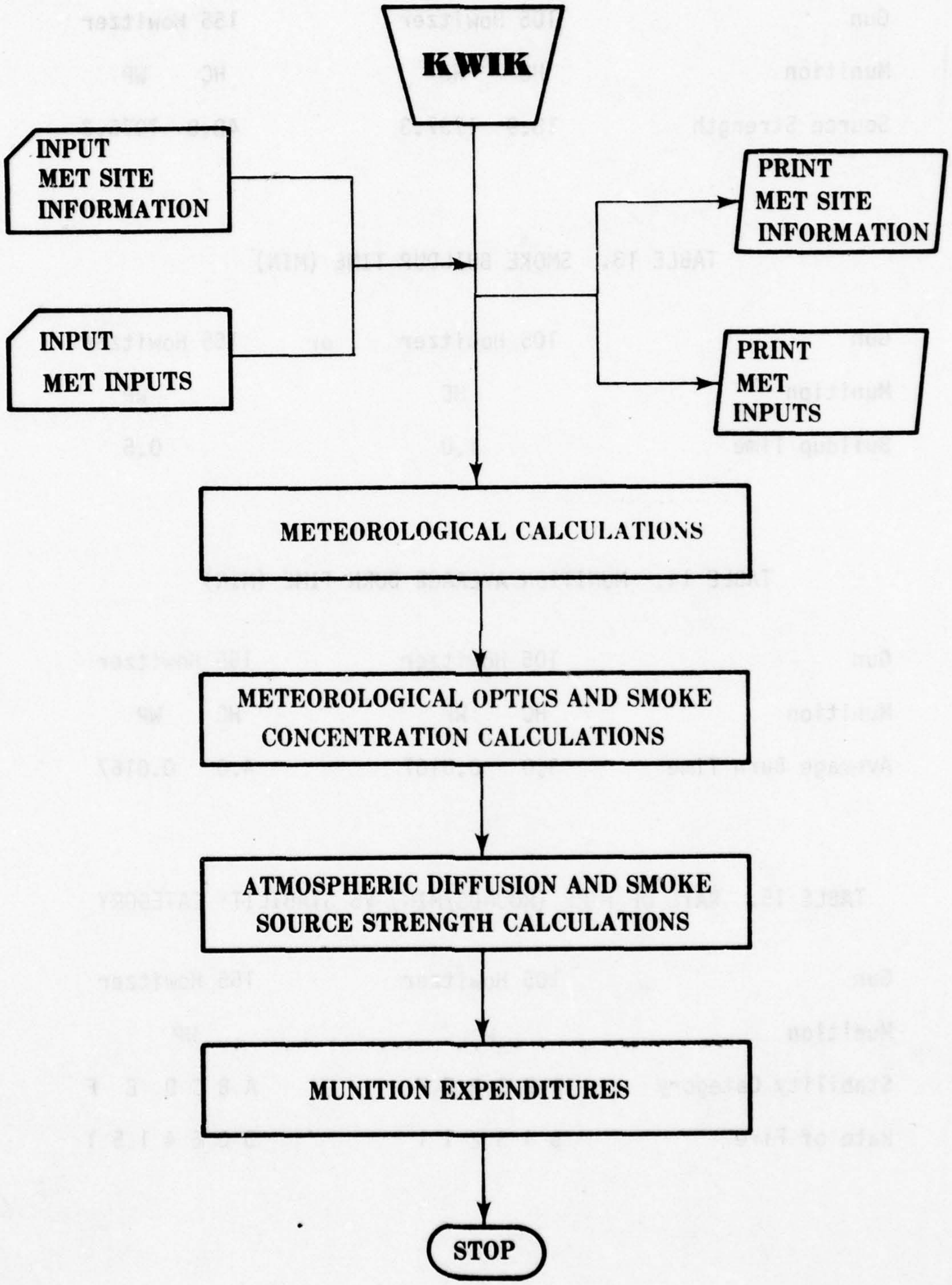
TABLE 14. MUNITION AVERAGE BURN TIME (MIN)

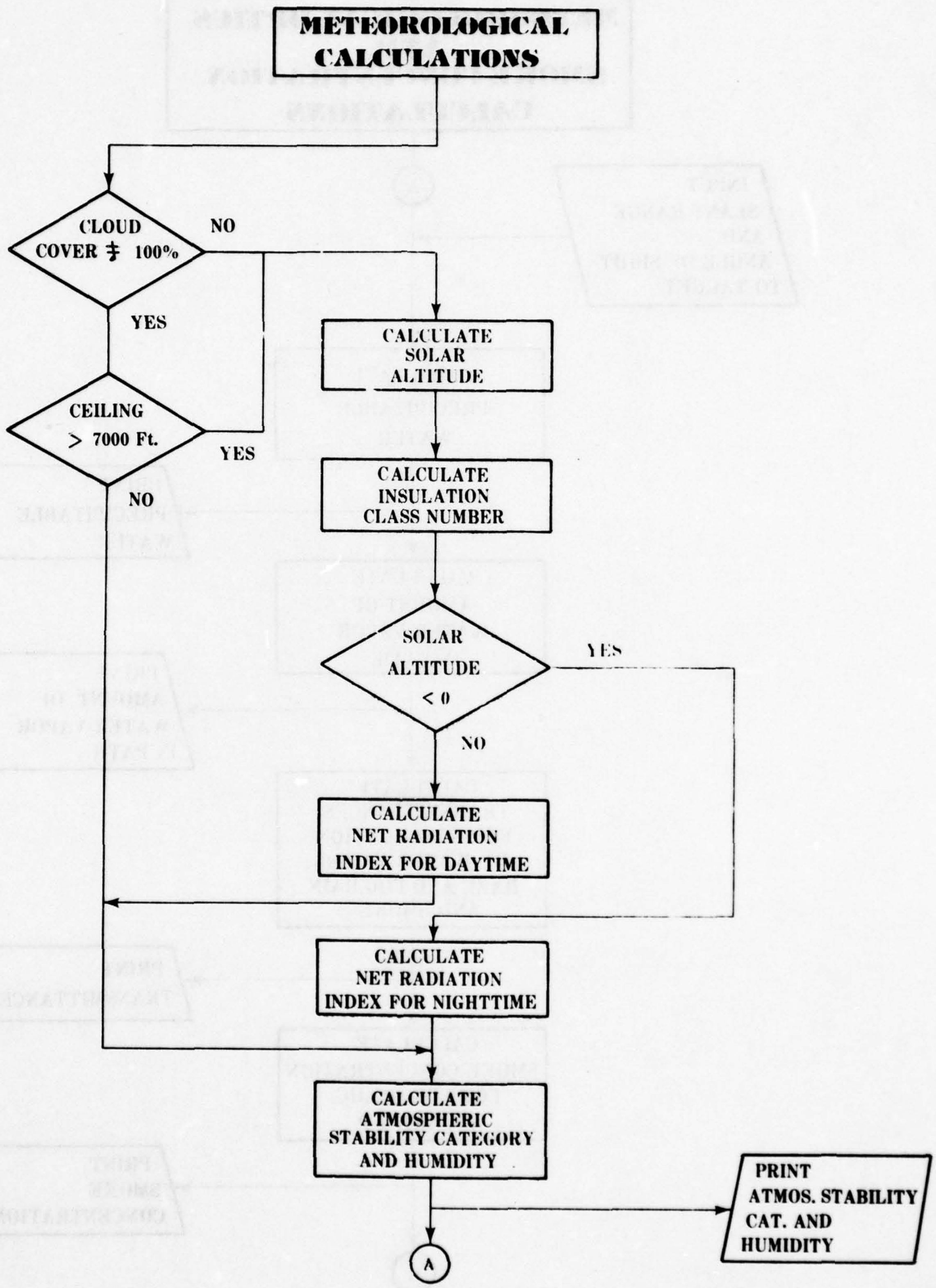
Gun	105 Howitzer		155 Howitzer	
Munition	HC	WP	HC	WP
Average Burn Time	3.0	0.0167	4.0	0.0167

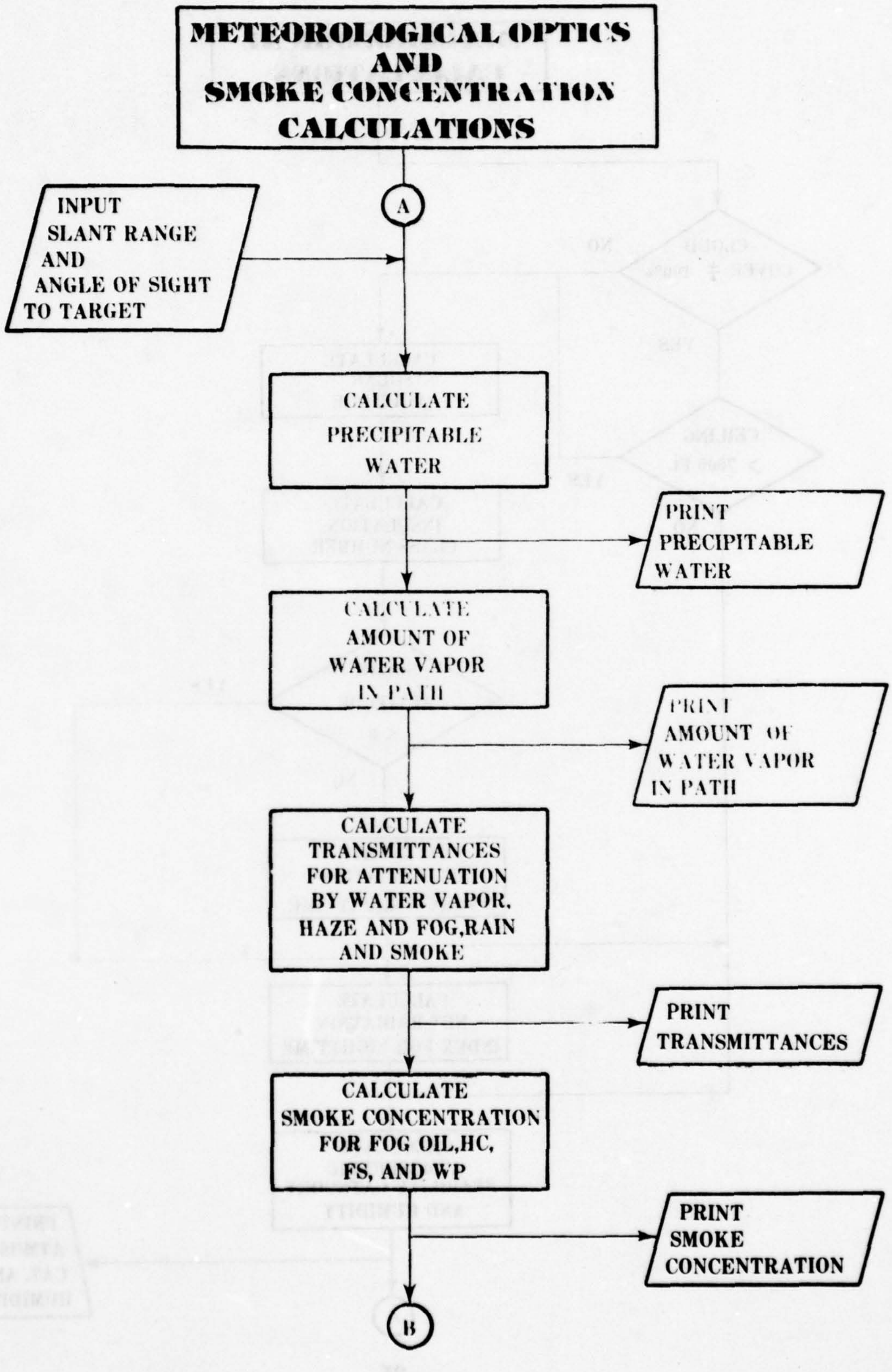
TABLE 15. RATE OF FIRE (ROUNDS/MIN) VS STABILITY CATEGORY

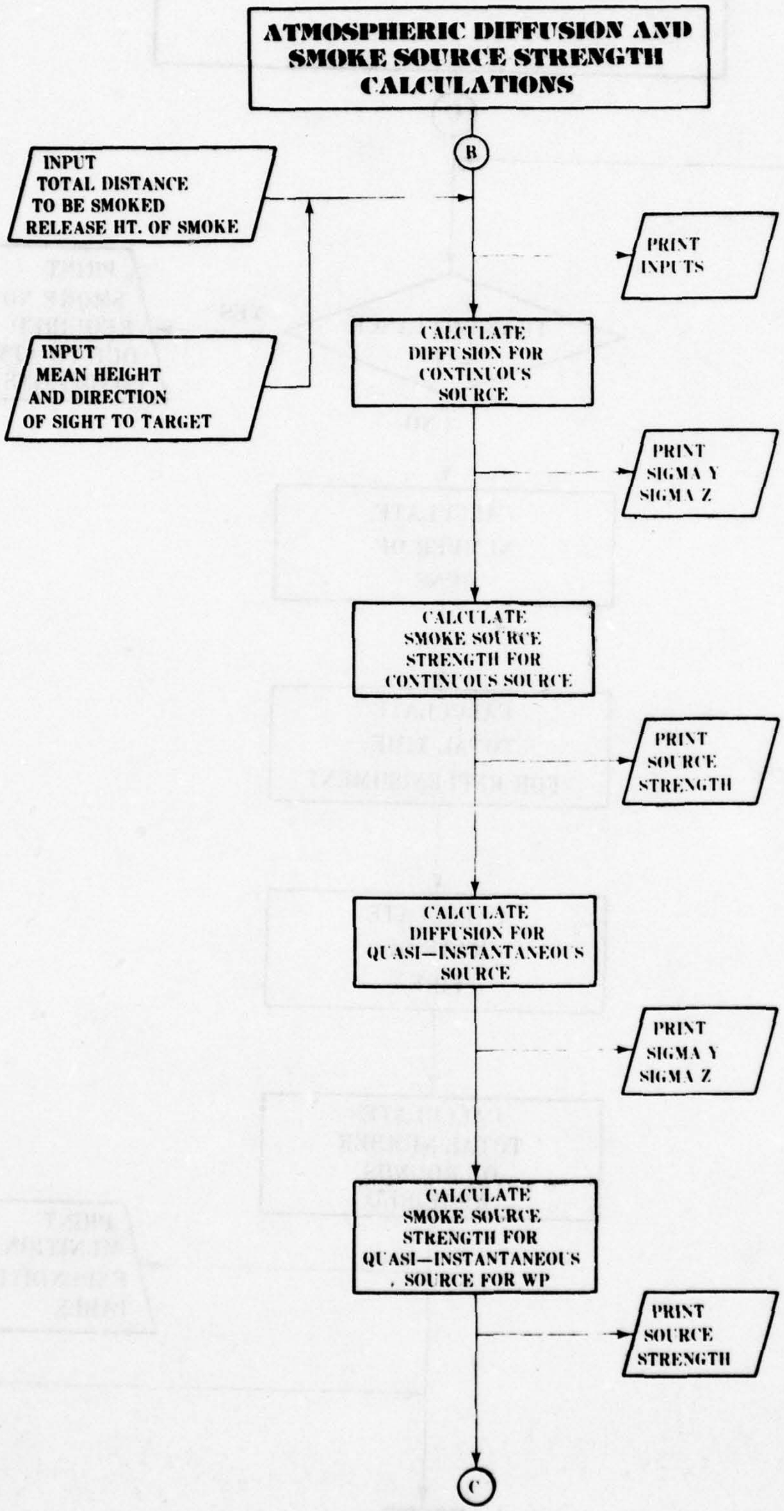
Gun	105 Howitzer						155 Howitzer					
Munition	HC						WP					
Stability Category	A	B	C	D	E	F	A	B	C	D	E	F
Rate of Fire	6	4	3	2	1	1	0	0	6	4	1.5	1

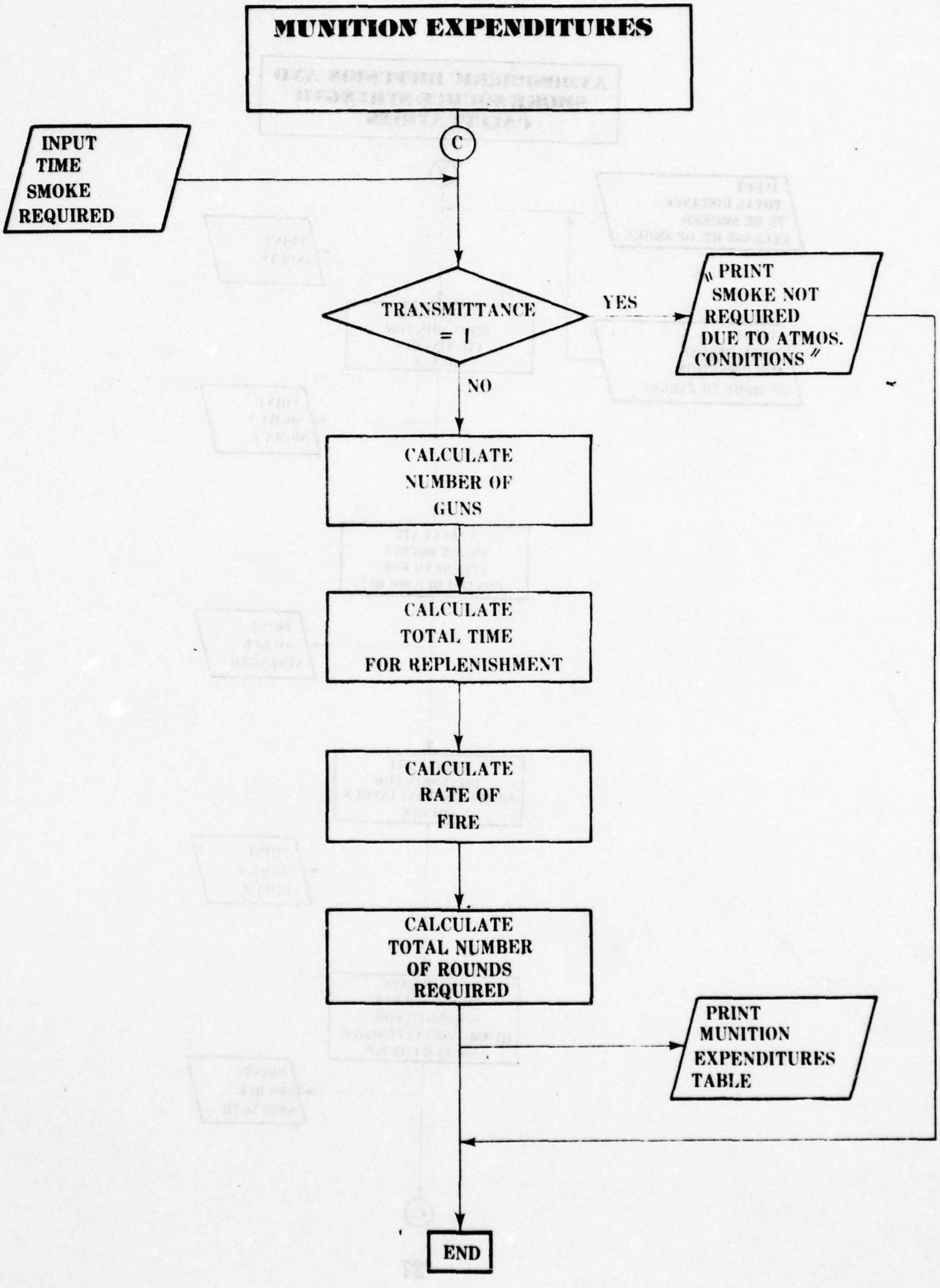
FLOWCHART


KWIK
INPUT MET SITE INFORMATION
INPUT MET INPUTS
PRINT MET SITE INFORMATION
PRINT MET INPUTS
METEOROLOGICAL CALCULATIONS
METEOROLOGICAL OPTICS AND SMOKE CONCENTRATION CALCULATIONS
ATMOSPHERIC DIFFUSION AND SMOKE SOURCE STRENGTH CALCULATIONS
MUNITION EXPENDITURES
STOP


METEOROLOGICAL CALCULATIONS
CLOUD COVER ≠ 100%
NO
YES
CEILING > 7000 Ft.
YES
NO
CALCULATE SOLAR ALTITUDE
CALCULATE INSULATION CLASS NUMBER
SOLAR ALTITUDE < 0
YES
NO
CALCULATE NET RADIATION INDEX FOR DAYTIME
CALCULATE NET RADIATION INDEX FOR NIGHTTIME
CALCULATE ATMOSPHERIC STABILITY CATEGORY AND HUMIDITY
PRINT ATMOS. STABILITY CAT. AND HUMIDITY
A


METEOROLOGICAL OPTICS AND SMOKE CONCENTRATION CALCULATIONS
A
INPUT SLANT RANGE AND ANGLE OF SIGHT TO TARGET
CALCULATE PRECIPITABLE WATER
PRINT PRECIPITABLE WATER
CALCULATE AMOUNT OF WATER VAPOR IN PATH
PRINT AMOUNT OF WATER VAPOR IN PATH
CALCULATE TRANSMITTANCES FOR ATTENUATION BY WATER VAPOR, HAZE AND FOG,RAIN AND SMOKE
PRINT TRANSMITTANCES
CALCULATE SMOKE CONCENTRATION FOR FOG OIL,HC, FS, AND WP
PRINT SMOKE CONCENTRATION
B


ATMOSPHERIC DIFFUSION AND SMOKE SOURCE STRENGTH CALCULATIONS
B
INPUT TOTAL DISTANCE TO BE SMOKED RELEASE HT. OF SMOKE
INPUT MEAN HEIGHT AND DIRECTION OF SIGHT TO TARGET
PRINT INPUTS
CALCULATE DIFFUSION FOR CONTINUOUS SOURCE
PRINT SIGMA Y SIGMA Z
CALCULATE SMOKE SOURCE STRENGTH FOR CONTINUOUS SOURCE
PRINT SOURCE STRENGTH
CALCULATE DIFFUSION FOR QUASI—INSTANTANEOUS SOURCE
PRINT SIGMA Y SIGMA Z
CALCULATE SMOKE SOURCE STRENGTH FOR QUASI—INSTANTANEOUS SOURCE FOR WP
PRINT SOURCE STRENGTH
C


MUNITION EXPENDITURES
C
INPUT TIME SMOKE REQUIRED
TRANSMITTANCE = 1
YES
NO
" PRINT SMOKE NOT REQUIRED DUE TO ATMOS. CONDITIONS "
CALCULATE NUMBER OF GUNS
CALCULATE TOTAL TIME FOR REPLENISHMENT
CALCULATE RATE OF FIRE
CALCULATE TOTAL NUMBER OF ROUNDS REQUIRED
PRINT MUNITION EXPENDITURES TABLE
END

ALGORITHM GLOSSARY OF MNEMONICS AND PROGRAM LISTINGS

FORTRAN

GLOSSARY OF MNEMONICS

CO	Ceiling - hundreds of feet
C1	Cloud cover - per cent
VO	Visibility - miles
TO	Temperature - degrees F
T1	Dew Point - degrees F
DO	Wind direction - tens of degrees
SO	Wind Speed Knots
PO	Atmospheric stability category
MO	Mixing depth height - meters
RO	Relative humidity - percent
XO	Total distance to be smoked - meters
T2	Time smoke required - minutes
Y	Average roughness element - centimeters
Z	Roughness length - centimeters
PSCTAB(7,9)	Table of stability categories (depending upon solar altitude and wind speed)
T(5,4)	Table of transmittances owing to water vapor, haze/fog, rain and smoke for 0.55,1.06, 2.3, 3.8, and 10.6 micrometers
C(5,4)	Table of smoke concentration values for fog oil, HC, FS, and WP for 0.55, 1.06, 2.3, 3.8 and 10.6 micrometers
B(5)	Error function absorption coefficients
G(5)	Scale height for Mie scattering
H(5)	Haze and fog attenuation coefficients
R(5)	Rain attenuation coefficients
CS(5,4,3)	Table of coefficients used to calculate smoke concentrations using the calculated transmittance values for 0.55, 1.06, 2.3, 3.8, and 10.6 micrometers
Q(5,4)	Smoke source strength values for fog oil, HC, FS, and WP for 0.55, 1.06, 2.3, 3.8, and 10.6 micrometers
A(6)	Coefficients to compute σy continuous source
S(6,4)	Coefficients of the roughness correction factor used in calculating σz for the various roughness lengths
Y1-Y4	Yield factors for fog oil, HC, FS, and WP
R(2,2)	Total number of rounds required to maintain smoke screen
G(2,2)	Number of guns
F(2,2)	Number of rounds per gun
H(2,2)	Unit (per gun) source strength
A(2,2)	Smoke build-up time
B(2,6)	Munition average burn time
D(2,6)	Rate of fire vs stability category for 105 Howitzer
E(2,6)	Rate of fire vs stability category for 155 Howitzer
W(2,2)	Total time for munition replenishment
SITE	Met observation station identifier
PSC(6)	Stability category indicator
WLNGTH(5)	Wavelength indicator
P	Precipitation indicator
D	Demo indicator

```
C*KWIK SMOKE PROGRAM.
      INTEGER P0
      COMMON /KWIK/ D,C0,C1,V0,P,T0,T1,D0,S0,Y,P0,R0,
     2              T(5,4),C(5,4),X0,Q(5,4)
      COMMON /MSITE/ SITE,SLAT,SLONG,SALT,SJDATE,SZHOUR
C*METEOROLOGICAL INPUTS.
      WRITE(6,10000)
      WRITE(6,10100)
      WRITE(6,10300)
      WRITE(6,10100)
      WRITE(3,10400)
      READ(5,10500) D
      WRITE(3,10600)
      READ(5,10500) SITE
      WRITE(3,10700)
      READ(5,10800) SLAT
      WRITE(3,10900)
      READ(5,10800) SLONG
      WRITE(3,11000)
      READ(5,10800) SALT
      WRITE(3,11100)
      READ(5,10800) SJDATE
      WRITE(3,11200)
      READ(5,10800) SZHOUR
      WRITE(6,11300)
      WRITE(6,10200)
      WRITE(6,11400) SITE
      WRITE(6,11500) SLAT
      WRITE(6,11600) SLONG
      WRITE(6,11700) SALT
      WRITE(6,10200)
      WRITE(6,11800) SJDATE
      WRITE(6,11900) SZHOUR
      WRITE(6,10100)
      WRITE(3,12000)
      READ(5,10800) C0
      C0=(C0*100.)*0.3048
      WRITE(3,12100)
      READ(5,10800) C1
      WRITE(3,12200)
      READ(5,10800) V0
      V0=V0*1.61
      WRITE(3,12300)
      READ(5,10500) P
      WRITE(3,12400)
      READ(5,10800) T0
      T0=(5./9.)*(T0-32.)
      WRITE(3,12500)
      READ(5,10800) T1
```

```
      T1=(5./9.)*(T1-32.)
      WRITE(3,12600)
      READ(5,10800) DD
      DD=DD*10.
      WRITE(3,12700)
      READ(5,10800) SU
      WRITE(3,12800)
      READ(5,10800) Y
      WRITE(6,12900)
      WRITE(6,10200)
      WRITE(6,13000) C0
      WRITE(6,13100) C1
      WRITE(6,13200) V0
      WRITE(6,13300) P
      WRITE(6,13400) T0
      WRITE(6,13500) T1
      WRITE(6,13600) DD
      WRITE(6,13700) SU
      WRITE(6,13800) Y
      WRITE(6,10100)
C*METEOROLOGICAL CALCULATIONS.
      CALL KWIK1
C*ATMOSPHERICS OPTICS AND SMOKE CONCENTRATIONS CALCULATIONS.
      CALL KWIK2
C*ATMOSPHERIC DIFFUSION AND SMOKE SOURCE STRENGTH CALCULATIONS.
      CALL KWIK3
C*MUNITIONS EXPENDITURES.
      CALL KWIK4
      WRITE(6,10000)
      STOP
C*FORMAT STATEMENTS.
10000 FORMAT(1H1)
10100 FORMAT(1H0)
10200 FORMAT(1H )
10300 FORMAT(19H KWIK SMOKE PROGRAM)
10400 FORMAT(16HDEMO - YES OR NO)
10500 FORMAT(A3)
10600 FORMAT(11HMET SITE ID)
10700 FORMAT(26HLATITUDE OF MET SITE - DEG)
10800 FORMAT(F10.0)
10900 FORMAT(27HLONGITUDE OF MET SITE - DEG)
11000 FORMAT(31HALTITUDE OF MET SITE KILOMETERS)
11100 FORMAT(30HJULIAN DATE OF MET OBSERVATION)
11200 FORMAT(31HZULU TIME OF MET OBSERVATION-HR)
11300 FORMAT(13H    MET SITE:)
11400 FORMAT(7X,21HID                    = ,3X,A3)
11500 FORMAT(7X,21HLATITUDE     - DEG    = ,F6.2)
11600 FORMAT(7X,21HLONGITUDE    - DEG    = ,F6.2)
11700 FORMAT(7X,21HALTITUDE     - KM     = ,F6.2)
11800 FORMAT(7X,21HJULIAN DATE - DAY     = ,F4.0)
```

```
11900 FORMAT(7X,20HZULU TIME  - HOUR = ,F4.0)
12000 FORMAT(27H CEILING - HUNDREDS OF FEET)
12100 FORMAT(22H CLOUD COVER - PERCENT)
12200 FORMAT(19H VISIBILITY - MILES)
12300 FORMAT(26H PRECIPITATION - YES OR NO)
12400 FORMAT(20H TEMPERATURE - DEG F)
12500 FORMAT(18H DEW POINT - DEF F)
12600 FORMAT(30H WIND DIRECTION - TENS OF DEGS)
12700 FORMAT(19H WIND SPEED - KNOTS)
12800 FORMAT(31H AVERAGE ROUGHNESS ELEMENT - CM)
12900 FORMAT(26H    METEOROLOGICAL INPUTS:)
13000 FORMAT(44H        CEILING                  - METERS     = ,F8.2)
13100 FORMAT(44H        CLOUD COVER              - PERCENT    = ,F8.2)
13200 FORMAT(44H        VISIBILITY               - KILOMETERS = ,F8.2)
13300 FORMAT(44H        PRECIPITATION                         = ,5X,A3)
13400 FORMAT(44H        TEMPERATURE              - DEG C      = ,F8.2)
13500 FORMAT(44H        DEW POINT                - DEG C      = ,F8.2)
13600 FORMAT(44H        WIND DIRECTION           - DEG        = ,F8.2)
13700 FORMAT(44H        WIND SPEED               - KNOTS      = ,F8.2)
13800 FORMAT(44H        AVE ROUGHNESS ELEMENT    - CM         = ,F8.2)
      END
```

```
      SUBROUTINE KWIKI
      COMMON /MSITE/ SITE,SLAT,SLONG,SALT,SJDATE,SZHOUR
      INTEGER PO
      COMMON /KWIK/ D,CO,C1,VO,P,TO,T1,DO,SO,Y,PO,RO,
     2            T(5,4),C(5,4),XO,Q(5,4)
      INTEGER PSCTAB
      DIMENSION PSCTAB(7,9),PSC(6)
      REAL MO
      DATA PI /3.141592654/
      DATA ((PSCTAB(I,J),I=1,7),J=1,9)/
     1         1,1,2,3,4,6,6,
     2         1,2,2,3,4,6,6,
     3         1,2,3,4,4,5,6,
     4         2,2,3,4,4,5,6,
     5         2,2,3,4,4,4,5,
     6         2,3,3,4,4,4,5,
     7         3,3,4,4,4,4,5,
     8         3,3,4,4,4,4,4,
     9         3,4,4,4,4,4,4/
      DATA PSC(1)/4HA    /,PSC(2)/4HB    /
      DATA PSC(3)/4HC    /,PSC(4)/4HD    /
      DATA PSC(5)/4HE    /,PSC(6)/4HF    /
C*METEOROLOGICAL CALCULATIONS.
      IF(C1 .NE. 100.) GO TO 1000
      IF(CO .GT. 2133.6042) GO TO 1000
      I1=0
      I2=0
      GO TO 2300
1000  CONTINUE
C CALCULATE ANGULAR FRACTION OF A YEAR FOR A GIVEN JULIAN DATE.
      R9=PI/180.
      D9=180./PI
      SLAT=SLAT*R9
      A0=((SJDATE-1.)*360.)/365.242
C CALCULATE SOLAR DECLINATION ANGLE (A4).
      A1=A0*R9
      A2=279.9348+A0
      A2=A2+(1.914827*SIN(A1))-(0.079525*COS(A1))
      A2=A2+(0.019938*SIN(2*A1))-(0.00162*COS(2*A1))
      A2=A2*R9
      A3=23.4438*R9
      A4=SIN(A3)*SIN(A2)
      A4=ASIN(A4)
C CALCULATE THE TIME OF MERIDIAN PASSAGE - TRUE SOLAR NOON (A5).
      A5= 12.+(0.12357*SIN(A1))-(0.004289*COS(A1))
      A5=A5+(0.153809*SIN(2*A1))+(0.060783*COS(2*A1))
C CALCULATE SOLAR HOUR ANGLE (A6).
      A6=15.*(SZHOUR-A5)-SLONG
      A6=A6*R9
```

```
C CALCULATE SOLAR ALTITUDE (A7).
      A7=SIN(SLAT)*SIN(A4)+COS(SLAT)*COS(A4)*COS(A6)
      A7=ASIN(A7)
C CALCULATE TIME OF SUNRISE AND SUNSET (B0,B1).
      A8=-1.76459*SALT**0.40795
      A8=A8*R9
      A9=(SIN(A8)-(SIN(SLAT)*SIN(A4)))/(COS(SLAT)*COS(A4))
      A9=ACOS(A9)
      A9=A9*D9
      A9=A9*(24./360.)
      B0=(SLONG/15.)+A5-A9
      B1=(SLONG/15.)+A5+A9
      IF(B1 .LE. 24.) GO TO 1100
      B1= B1-24.
1100  CONTINUE
      A7=A7*D9
C CALCULATE INSOLATION CLASS NUMBER.
      I2=0
      IF(A7 .LE. 60.) GO TO 1200
      I2=4
      GO TO 1500
1200  CONTINUE
      IF(A7 .LE. 35.) GO TO 1300
      I2=3
      GO TO 1500
1300  CONTINUE
      IF(A7 .LE. 15.) GO TO 1400
      I2=2
      GO TO 1500
1400  CONTINUE
      IF(A7 .LE. 0.) GO TO 2200
      I2=1
C CALCULATE NET RADIATION INDEX FOR DAYTIME.
1500  CONTINUE
      I3=0
      IF(C1 .GT. 50.) GO TO 1600
      I3=I2
      GO TO 1900
1600  CONTINUE
      IF(C0 .GT. 2133.6042) GO TO 1700
      I3=I2-2
      GO TO 1900
1700  CONTINUE
      IF(C0 .GE. 4876.8096) GO TO 1800
      I3=I2-1
      GO TO 1900
1800  CONTINUE
      IF(C1 .NE. 100.) GO TO 1900
      I3=I2-1
1900  CONTINUE
```

```
      IF(I3 .NE. 0) GO TO 2000
      I3=12
2000  CONTINUE
      IF(I3 .GT. 1) GO TO 2100
      I3=1
2100  CONTINUE
      I1=I3
      GO TO 2300
C COMPUTE NET RADIATION INDEX FOR NIGHTTIME.
2200  CONTINUE
      IF(C1 .GT. 40.) GO TO 2250
      I1=-2
      GO TO 2300
2250  CONTINUE
      I1=-1
C CALCULATE PASQUILL STABILITY CATAGORY.
2300  CONTINUE
      I4=0
      I5=0
      IF(I1 .NE. 4) GO TO 2400
      I4=1
2400  CONTINUE
      IF(I1 .NE. 3) GO TO 2420
      I4=2
2420  CONTINUE
      IF(I1 .NE. 2 ) GO TO 2440
      I4=3
2440  CONTINUE
      IF(I1 .NE. 1) GO TO 2460
      I4=4
2460  CONTINUE
      IF(I1 .NE. 0) GO TO 2480
      I4=5
2480  CONTINUE
      IF(I1 .NE. -1) GO TO 2500
      I4=6
2500  CONTINUE
      IF(I1 .NE. -2) GO TO 2520
      I4=7
2520  CONTINUE
      IF(S0 .GE. 2.) GO TO 2540
      I5=1
2540  CONTINUE
      IF(S0 .GE. 4.) GO TO 2560
      I5=2
      GO TO 2700
2560  CONTINUE
      IF(S0 .GE. 6.) GO TO 2580
      I5=3
      GO TO 2700
```

```
2580  CONTINUE
      IF(S0 .GE. 7.) GO TO 2600
      IS=4
      GO TO 2700
2600  CONTINUE
      IF(S0 .GE. 8.) GO TO 2620
      IS=5
      GO TO 2700
2620  CONTINUE
      IF(S0 .GE. 10.) GO TO 2640
      IS=6
      GO TO 2700
2640  CONTINUE
      IF(S0 .GE. 11.) GO TO 2660
      IS=7
      GO TO 2700
2660  CONTINUE
      IF(S0 .GE. 12.) GO TO 2680
      IS=8
      GO TO 2700
2680  CONTINUE
      IS=9
2700  CONTINUE
      P0=PSCTAB(I4,IS)
C CALCULATE MIXING DEPTH HEIGHT.
      P1=P0
      M0=(6.-P1)*121.*(T0-T1)/6.+(P1*0.087*(S0+0.5))
     1           /(12.*8.237E-05*5.809)
C CALCULATE RELATIVE HUMIDITY.
      IF(T0 .GT. 0.) GO TO 2800
      A0=9.5
      B0=265.5
      IF(T0 .LE. 0.) GO TO 2850
2800  CONTINUE
      A0=7.5
      B0=237.3
2850  CONTINUE
      IF(T1 .GE. 0.) GO TO 2900
      A1=9.5
      B1=265.5
      IF(T1 .LE. 0.) GO TO 2950
2900  CONTINUE
      A1=7.5
      B1=237.3
2950  CONTINUE
      E0=6.11*10.**((A0*T0)/(B0+T0))
      E1=6.11*10.**((A1*T1)/(B1+T1))
      R0=(E1/E0)*100.
      WRITE(6,20000)
      WRITE(6,10200)
```

```
      WRITE(6,20100) PSC(P0)
      WRITE(6,20200) RO
      WRITE(6,10100)
C*FORMAT STATEMENTS.
10100 FORMAT(1H0)
10200 FORMAT(1H )
20000 FORMAT(32H    METEOROLOGICAL CALCULATIONS:)
20100 FORMAT(40H        ATMOSPHERIC STABILITY CATEGORY = ,5X,A1)
20200 FORMAT(40H        RELATIVE HUMIDITY              = ,F6.2)
      RETURN
      END
```

```
      SUBROUTINE KWIK2
      INTEGER PU
      COMMON /KWIK/ D,C0,C1,V0,P,T0,T1,D0,S0,Y,P0,R0,
     2              T(5,4),C(5,4),X0,Q(5,4)
      COMMON /OUTPUT/ WLNGTH(5)
      DIMENSION B(5),G(5),H(5),R(5),CS(5,4,3)
      REAL L0,L1,L2,L3,L4,L5
      REAL NO
      DATA B/0.118,0.22,0.14,0.55,0.0/
      DATA G/26.7,13.0,5.3,5.1,5.0/
      DATA CS(1,1,1)/0.0093/,CS(1,1,2)/-0.3428/,CS(1,1,3)/-0.0009/
      DATA CS(1,2,1)/0.0119/,CS(1,2,2)/-0.2747/,CS(1,2,3)/-0.0013/
      DATA CS(1,3,1)/0.0142/,CS(1,3,2)/-0.1110/,CS(1,3,3)/0.00004/
      DATA CS(1,4,1)/0.0055/,CS(1,4,2)/-0.1541/,CS(1,4,3)/-0.0004/
      DATA CS(2,1,1)/0.0093/,CS(2,1,2)/-0.3428/,CS(2,1,3)/-0.0009/
      DATA CS(2,2,1)/0.0119/,CS(2,2,2)/-0.2747/,CS(2,2,3)/-0.0013/
      DATA CS(2,3,1)/0.0142/,CS(2,3,2)/-0.1110/,CS(2,3,3)/0.00004/
      DATA CS(2,4,1)/0.0055/,CS(2,4,2)/-0.1541/,CS(2,4,3)/-0.0004/
      DATA CS(3,1,1)/0.0093/,CS(3,1,2)/-0.3428/,CS(3,1,3)/-0.0009/
      DATA CS(3,2,1)/0.0119/,CS(3,2,2)/-0.2747/,CS(3,2,3)/-0.0013/
      DATA CS(3,3,1)/0.0142/,CS(3,3,2)/-0.1110/,CS(3,3,3)/0.00004/
      DATA CS(3,4,1)/0.0055/,CS(3,4,2)/-0.1541/,CS(3,4,3)/-0.0004/
      DATA CS(4,1,1)/0.0093/,CS(4,1,2)/-0.3428/,CS(4,1,3)/-0.0009/
      DATA CS(4,2,1)/0.0119/,CS(4,2,2)/-0.2747/,CS(4,2,3)/-0.0013/
      DATA CS(4,3,1)/0.0142/,CS(4,3,2)/-0.1110/,CS(4,3,3)/0.00004/
      DATA CS(4,4,1)/0.0055/,CS(4,4,2)/-0.1541/,CS(4,4,3)/-0.0004/
      DATA CS(5,1,1)/0.0093/,CS(5,1,2)/-0.3428/,CS(5,1,3)/-0.0009/
      DATA CS(5,2,1)/0.0119/,CS(5,2,2)/-0.2747/,CS(5,2,3)/-0.0013/
      DATA CS(5,3,1)/0.0142/,CS(5,3,2)/-0.1110/,CS(5,3,3)/0.00004/
      DATA CS(5,4,1)/0.0055/,CS(5,4,2)/-0.1541/,CS(5,4,3)/-0.0004/
      DATA PI /3.141592654/
      DATA NO/2HNO/
      DATA YES/3HYES/
      FNA(A)=EXP(-S*A/2)
      FNB(B)=EXP(-B**2)
      FNC(C)=EXP(+C*S*ALOG(0.1/H(J)))
      FND(D)=EXP(-D*S/4.1)
C*ATMOSPHERICS OPTICS AND SMOKE CONCENTRATIONS CALCULATIONS.
      IF(D .EQ. YES)  GO TO 3000
      WRITE(6,10000)
      WRITE(6,30000)
      WRITE(6,10200)
3000  CONTINUE
      V1=ALOG(V0)
      V2=V1*V1
      V3=V2*V1
      H(1)=1.5551-(0.9811*V1)-(0.0197*V2)+(0.0041*V3)
      H(1)=EXP(H(1))
      H(2)=1.5551-(0.9811*V1)-(0.0197*V2)+(0.0041*V3)
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      H(2)=EXP(H(2))
      H(3)=1.4491-(1.0044*V1)-(0.012*V2)+(0.0032*V3)
      H(3)=EXP(H(3))
      H(4)=1.2394-(1.0436*V1)+(0.0099*V2)-(0.0016*V3)
      H(4)=EXP(H(4))
      H(5)=1.5176-(1.7147*V1)+(0.0001*V2)+(0.0428*V3)
      H(5)=EXP(H(5))
      R(1)=1.3306-(0.8825*V1)-(0.0753*V2)+(0.0129*V3)
      R(1)=EXP(R(1))
      R(2)=1.4098-(0.9865*V1)-(0.014*V2)+(2.3E-03*V3)
      R(2)=EXP(R(2))
      R(3)=1.5497-(0.8896*V1)-(0.1084*V2)+(0.0231*V3)
      R(3)=EXP(R(3))
      R(4)=1.5556-(0.9013*V1)-(0.0773*V2)+(0.0173*V3)
      R(4)=EXP(R(4))
      R(5)=1.5928-(0.9396*V1)-(0.0627*V2)+(0.0168*V3)
      R(5)=EXP(R(5))
      H0=0.0
      WRITE(5,31000)
      READ(5,10800) H3
      WRITE(5,32000)
      READ(5,10800) S
      IF(D .EQ. YES)  GO TO 3100
      WRITE(6,34000) H3
      WRITE(6,35000) S
      WRITE(6,10200)
3100  CONTINUE
      H3=H3/1000.
      IF(S .LT. 0.) S=-S
      S=S*(PI/180.)
      H1=SIN(S)*H3
      H2=COS(S)*H3
      S=SIN(S)
      H4=0.
      IF(S .NE. 0.) H4=1./S
C CALCULATE PRECIPITABLE WATER.
      W=0.4477+(0.0328*T1)+(1.2E-03*T1*T1)+(1.84E-05*T1*T1*T1)
      IF(D .EQ. YES)  GO TO 3300
      WRITE(6,36000) W
3300  CONTINUE
C CALCULATE AMOUNT OF WATER VAPOR IN PATH.
      L0=H3
      L1=H0
      L2=L0
      L3=0.5*(L1+L2)
      L4=L2-L1
      L5=0.2886751*L4
      W0=0.5*L4*(FNA(L3+L5)+FNA(L3-L5))
      W1=W*W0
      IF(D .EQ. YES)  GO TO 3400
```

```
      WRITE(6,36500) W1
 3400 CONTINUE
C CALCULATE TRANSMITTANCES FOR 0.55,1.06,2.3,3.8,10.6 MICRON WAVELENGTHS
      DO 5400 J=1,5
      IF(D .EQ. YES)  GO TO 3500
      WRITE(6,10200)
      WRITE(6,46000) WLNGTH(J)
      WRITE(6,10200)
 3500 CONTINUE
      IF(J .NE. 5) GO TO 3600
      T(J,1)=EXP(-0.0681*W)
      GO TO 3700
C CALCULATE TRANSMITTANCE OWING TO ABSORPTION BY WATER VAPOR.
 3600 CONTINUE
      L0=(B(J)*SQRT(W1*PI)/2.)
      L1=H0
      L2=L0
      L3=0.5*(L1+L2)
      L4=L2-L1
      L5=0.2886751*L4
      T2=0.5*L4*(FNB(L3+L5)+FNB(L3-L5))
      T(J,1)=(2./SQRT(PI))*T2
      T(J,1)=1-T(J,1)
 3700 CONTINUE
      IF(D .EQ. YES)  GO TO 3800
      WRITE(6,37000) T(J,1)
 3800 CONTINUE
C CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY HAZE AND FOG.
      IF(P .EQ. NO)  GO TO 3900
      T(J,2)=1.0
      GO TO 4100
 3900 CONTINUE
      IF(V0 .GT. G(J))  GO TO 4000
      L0=H4
      L1=H0
      L2=L0
      L3=0.5*(L1+L2)
      L4=L2-L1
      L5=0.2886751*L4
      T3=0.5*L4*(FNC(L3+L5)+FNC(L3-L5))
      T4=EXP(-H(J)*T3)
      L0=H3-H4
      L1=H4
      L2=H4+L0
      L3=0.5*(L1+L2)
      L4=L2-L1
      L5=0.2886751*L4
      T5=0.5*L4*(FND(L3+L5)+FND(L3-L5))
      T6=EXP(-0.128*T5)
      T(J,2)=T4*T6
```

```
      GO TO 4100
4000  CONTINUE
      L0=H3
      L1=H0
      L2=L0
      L3=0.5*(L1+L2)
      L4=L2-L1
      L5=0.2886751*L4
      T7=0.5*L4*(FND(L3+L5)+FND(L3-L5))
      T(J,2)=EXP(-H(J)*T7)
4100  CONTINUE
      IF(D .EQ. YES)  GO TO 4200
      WRITE(6,38000) T(J,2)
C CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY RAIN.
4200  CONTINUE
      IF(P .EQ. YES)  GO TO 4400
4300  CONTINUE
      T(J,3)=1.
      GO TO 4500
4400  CONTINUE
      IF(V0 .GT. 20.)  GO TO 4300
      T(J,3)=EXP(-H3*R(J))
4500  CONTINUE
      IF(D .EQ. YES)  GO TO 4600
      WRITE(6,39000) T(J,3)
C CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY SMOKE.
4600  CONTINUE
      T(J,4)=0.02/(T(J,1)*T(J,2)*T(J,3))
      IF(T(J,4) .LE. 1.)  GO TO 4700
      T(J,4)=1.
4700  CONTINUE
      IF(D .EQ. YES)  GO TO 4800
      WRITE(6,40000) T(J,4)
      WRITE(6,10200)
C CALCULATE SMOKE CONCENTRATION.
4800  CONTINUE
      IF(T(J,4) .NE. 1.)  GO TO 5000
      DO 4900 I=1,4
      C(J,I)=0.
4900  CONTINUE
      GO TO 5200
5000  CONTINUE
      T8=ALOG(T(J,4))
      T9=T8*T8
      DO 5100 K=1,4
      C(J,K)=CS(J,K,1)+CS(J,K,2)*T8+CS(J,K,3)*T9
5100  CONTINUE
5200  CONTINUE
      IF(D .EQ. YES)  GO TO 5300
      WRITE(6,41000) C(J,1)
```

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      WRITE(6,42000) C(J,2)
      WRITE(6,43000) C(J,3)
      WRITE(6,44000) C(J,4)
5300  CONTINUE
5400  CONTINUE
      IF(D .EQ. YES)  GO TO 5500
      WRITE(6,10100)
5500  CONTINUE
      RETURN
C*FORMAT STATEMENTS.
10000 FORMAT(1H1)
10100 FORMAT(1H0)
10200 FORMAT(1H )
10800 FORMAT(F10.0)
30000 FORMAT(26H    ATMOSPHERIC OPTICS AND,
     2        34H SMOKE CONCENTRATION CALCULATIONS:)
31000 FORMAT(31H SLANT RANGE TO TARGET - METERS)
32000 FORMAT(31H ANGLE OF SIGHT TO TARGET - DEG)
34000 FORMAT(49H          SLANT RANGE TO TARGET              - METERS = ,F8.2)
35000 FORMAT(49H          ANGLE OF SIGHT TO TARGET           - DEG    = ,F8.2)
36000 FORMAT(49H          PRECIPITABLE WATER                 - CM/KM  = ,F8.2)
36500 FORMAT(49H          AMOUNT OF WATER VAPOR IN PATH      - CM     = ,F8.2)
37000 FORMAT(47H          TRANSMITTANCE OWING TO ATTENUATION BY:  ,
     2               14HWATER VAPOR = ,F6.2)
38000 FORMAT(47X,14HHAZE/FOG    = ,F6.2)
39000 FORMAT(47X,14HRAIN        = ,F6.2)
40000 FORMAT(47X,14HSMOKE       = ,F6.2)
41000 FORMAT(7X,42HSMOKE CONCENTRATION:  FOG OIL - GM/SQ M = ,F6.2)
42000 FORMAT(29X,20HHC        - GM/SQ M = ,F6.2)
43000 FORMAT(29X,20HFS        - GM/SQ M = ,F6.2)
44000 FORMAT(29X,20HWP        - GM/SQ M = ,F6.2)
46000 FORMAT(4X,A4,13H MICROMETERS:)
      END
```

```
      SUBROUTINE KWIKS
      INTEGER P0
      COMMON /KWIK/ D,C0,C1,V0,P,T0,T1,D0,S0,Y,P0,R0,
     2              T(5,4),C(5,4),X0,Q(5,4)
      COMMON /OUTPUT/ WLNGTH(5)
      DIMENSION A(6),S(6,4)
      DATA A/0.4,0.32,0.22,0.144,0.102,0.076/
      DATA S/0.112,0.13,0.112,0.098,0.0609,0.0638,
     2      1.06,0.95,0.92,0.889,0.895,0.783,
     3      5.38E-04,6.52E-04,9.05E-04,1.35E-03,1.96E-03,1.36E-03,
     4      0.815,0.75,0.718,0.688,0.684,0.672/
      DATA PI /3.141592654/
      DATA YES/3HYES/
C*ATMOSPHERIC DIFFUSION AND SMOKE SOURCE STRENGTH CALCULATIONS.
      WRITE(6,10000)
      IF(D .EQ. YES)  GO TO 5000
      WRITE(6,50000)
      WRITE(6,10200)
 5000 CONTINUE
      WRITE(3,51000)
      READ(5,12000) X0
      WRITE(3,51500)
      READ(5,12000) H0
      WRITE(3,52000)
      READ(5,12000) Z0
      WRITE(3,52500)
      READ(5,12000) A0
      IF(D .EQ. YES)  GO TO 5100
      WRITE(6,53000) X0
      WRITE(6,53500) H0
      WRITE(6,54000) Z0
      WRITE(6,54500) A0
 5100 CONTINUE
C DIFFUSION CALCULATIONS FOR CONTINUOUS SOURCE.
      A1=-1.24+1.19*ALOG10(Y)
      Z=10.**A1
      B1=ALOG(Z)
      B2=B1*B1
      B3=B2*B1
      B4=B3*B1
      B5=B4*B1
      B6=0.444685869+0.294049265*B1-0.237213914*B2
      B7=0.155349504*B3-0.032015723*B4+2.15168E-03*B5
      D1=B6+B7
      D1=EXP(D1)
      B6=-1.298283909-1.006186784*B1+1.485094886*B2
      B7=-0.774136725*B3+0.156559355*B4-0.010823351*B5
      D2=B6+B7
      D2=EXP(D2)-0.225
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      IF(Z .GT. 9.999999) GO TO 5200
      B6=5.77267E-04+2.31943E-05*B1+3.71041E-05*B2
      B7=-8.40602E-06*B3+1.3421E-07*B4+2.55131E-08*B5
      GO TO 5220
5200  CONTINUE
      IF(Z .GT. 40.) GO TO 5210
      B6=-11.56134901+2.148242814*B1-0.156210817*B2
      B7=7.03582E-03*B3-1.47353E-04*B4+1.18256E-06*B5
      GO TO 5220
5210  CONTINUE
      B6=1108.386588-103.5495836*B1+2.424499256*B2
      B7=-0.014584773*B3+4.34517E-05*B4-4.69556E-08*B5
5220  CONTINUE
      D3=B6+B7
      B6=0.500775609+1.092614788*B1-1.573065836*B2
      B7=0.724276579*B3-0.140820904*B4+9.61621E-03*B5
      D4=B6+B7
      D4=EXP(D4)-1.2
      IF(Z .GT. 10.)  GO TO 5230
      B1=ALOG(D1*X0**D2*1/(1+D3*X0**D4))
      GO TO 5240
5230  CONTINUE
      B1=ALOG(D1*X0**D2*(1+1/(D3*X0**D4)))
5240  CONTINUE
      B2=S(P0,1)*X0**S(P0,2)/(1+S(P0,3)*X0**S(P0,4))
      S2=B1*B2
      S1=A(P0)*X0**0.9
      IF(D .EQ. YES)  GO TO 5250
      WRITE(6,10200)
      WRITE(6,60000)
      WRITE(6,10200)
      WRITE(6,55000) S1
      WRITE(6,55500) S2
5250  CONTINUE
C SMOKE SOURCE STRENGTH CALCULATIONS FOR CONTINUOUS SOURCE.
      A2=ABS(A0-D0)*(PI/180.)
      IF(S0 .NE. 0.) GO TO 5300
      S0=1.0
5300  CONTINUE
      S3=S0*0.515
      Q0=S2*S3*SQRT(PI)/SQRT(2)*EXP(-0.5*((Z0-H0)/S2)**2)
      R2=SQRT(3.3124/(6.76*SIN(A2)*SIN(A2)+0.49*COS(A2)*COS(A2)))
      Y2=0.9337+(0.0369*R0)-(7E-04*R0*R0)+(6.11E-06*R0*R0*R0)
      Y3=1.3775+(0.09868*R0)-(1.8E-03*R0*R0)+(1.56E-05*R0*R0*R0)
      Q0=Q0*R2
      Q1=Q0/Y2
      Q2=Q0/Y3
      DO 5400 I=1,5
      Q(I,1)=C(I,1)*Q0
      Q(I,2)=C(I,2)*Q1
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      Q(I,3)=C(I,3)*Q2
      IF(D .EQ. YES)  GO TO 5400
      WRITE(6,10200)
      WRITE(6,59000)  WLNGTH(I)
      WRITE(6,10200)
      WRITE(6,56000) Q(I,1)
      WRITE(6,56500) Q(I,2)
      WRITE(6,57000) Q(I,3)
5400  CONTINUE
C DIFFUSION CALCULATIONS FOR QUASI-INSTANTANEOUS SOURCE.
      S1=2./3.*S1
      S2=2./3.*S2
      IF(D .EQ. YES)  GO TO 5500
      WRITE(6,10200)
      WRITE(6,61000)
      WRITE(6,10200)
      WRITE(6,55000) S1
      WRITE(6,55500) S2
5500  CONTINUE
C SMOKE SOURCE STRENGTH CALCULATIONS FOR QUASI-INSTANTANEOUS SOURCE.
      Q0=(S1*S2*PI)/EXP(-(Z0*Z0-H0*H0)/(2*S2*S2))
      Y4=3.2489+(0.0774*R0)-(1.6E-03*R0*R0)+(1.73E-05*R0*R0*R0)
      Q0=(Q0/Y4)*10
      DO 5600 I=1,5
      Q(I,4)=C(I,4)*Q0
      IF(D .EQ. YES)  GO TO 5600
      WRITE(6,10200)
      WRITE(6,59000) WLNGTH(I)
      WRITE(6,10200)
      WRITE(6,58500) Q(I,4)
5600  CONTINUE
      IF(D .EQ. YES)  GO TO 5700
      WRITE(6,10100)
5700  CONTINUE
      RETURN
C*FORMAT STATEMENTS.
10000 FORMAT(1H1)
10100 FORMAT(1H0)
10200 FORMAT(1H )
12000 FORMAT(F10.0)
50000 FORMAT(4X,38HATMOSPHERIC DIFFUSION AND SMOKE SOURCE,
    2            23H STRENGTH CALCULATIONS:)
51000 FORMAT(32H TOTAL DISTANCE TO BE SMOKED - M)
51500 FORMAT(31H RELEASE HEIGHT OF SMOKE SOURCE)
52000 FORMAT(31H MEAN HEIGHT OF TARGET - METERS)
52500 FORMAT(31H DIRECTION OF LINE OF SIGHT-DEG)
53000 FORMAT(7X,27HTOTAL DISTANCE TO BE SMOKED,10X,11H- METERS = ,F8.2)
53500 FORMAT(7X,36HRELEASE HEIGHT OF SMOKE SOURCE (AGL),
    2             12H - METERS = ,F8.2)
54000 FORMAT(7X,21HMEAN HEIGHT OF TARGET,16X,11H- METERS = ,F8.2)
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54500 FORMAT(7X,36HDIRECTION OF LINE OF SIGHT TO TARGET,
     2              12H - DEG      = ,F8.2)
55000 FORMAT(7X,19HSIGMA Y - METERS = ,F8.2)
55500 FORMAT(7X,19HSIGMA Z - METERS = ,F8.2)
56000 FORMAT(7X,38HSOURCE STRENGTH:  FOG OIL - GMS/SEC = ,F6.2)
56500 FORMAT(25X,20HHC         - GMS/SEC = ,F6.2)
57000 FORMAT(25X,20HFS         - GMS/SEC = ,F6.2)
58500 FORMAT(7X,40HSTRENGTH FOR QUASI-INSTANTANEOUS SOURCE:,
     2            17H  WP - GMS/SEC = ,F6.2)
59000 FORMAT(4X,A4,13H MICROMETERS:)
60000 FORMAT(4X,18HCONTINOUS SOURCE:)
61000 FORMAT(4X,27HQUASI-INSTANTANEOUS SOURCE:)
      END
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      SUBROUTINE KWIK4
      INTEGER P0
      COMMON /KWIK/ D,C0,C1,V0,P,T0,T1,D0,S0,Y,P0,R0,
     2              T(5,4),C(5,4),X0,Q(5,4)
      COMMON /OUTPUT/ WLENGTH(5)
      DIMENSION G(2,2),H(2,2),W(2,2),A(2,2),B(2,2)
      DIMENSION D1(2,6),E(2,6),F(2,2),R(2,2)
      DATA ((H(I,J),J=1,2),I=1,2)/18.9,1737.3,48.8,7076.2/
      DATA ((A(I,J),J=1,2),I=1,2)/1.,0.5,1.,0.5/
      DATA ((B(I,J),J=1,2),I=1,2)/3.,0.0167,4.,0.0167/
      DATA ((D1(I,J),J=1,6),I=1,2)/6.,4.,3.,2.,1.,1.,0.,0.,6.,4.,1.5,1.
      DATA ((E(I,J),J=1,6),I=1,2)/3.,2.,1.5,1.,0.5,0.333,
     1                            0.,0.,3.,2.,0.5,0.333/
      DATA YES/3HYES/
C*MUNITIONS EXPENDITURES.
      WRITE(6,10000)
      WRITE(6,60000)
      WRITE(6,10200)
      WRITE(5,60500)
      READ(5,12000) T2
      DO 6800 K=1,5
      IF(K .EQ. 1) GO TO 6000
      IF(J. EQ. YES)  GO TO 6900
 6000 CONTINUE
      IF(T(K,4) .EQ. 1.) GO TO 6750
C CALCULATE NUMBER OF GUNS REQUIRED.
      G(1,1)=Q(K,2)/H(1,1)
      G(1,2)=Q(K,5)/H(1,2)
      G(2,1)=Q(K,2)/H(2,1)
      G(2,2)=Q(K,5)/H(2,2)
      DO 6200 I=1,2
      DO 6100 J=1,2
      G0=AINT(G(I,J))
      G1=G(I,J)-G0
      IF(G1 .EQ. 0.) GO TO 6100
      G(I,J)=G0+1
 6100 CONTINUE
 6200 CONTINUE
C CALCULATE TOTAL TIME FOR REPLENISHMENT.
      DO 6400 I=1,2
      DO 6300 J=1,2
      W(I,J)=T2+A(I,J)-B(I,J)
 6300 CONTINUE
 6400 CONTINUE
C CALCULATE RATE OF FIRE.
      DO 6500 J=1,2
      F(1,J)=(W(1,J)*D1(J,P0))+1
      F(2,J)=(W(2,J)*E(J,P0))+1
 6500 CONTINUE
```

```
C CALCULATE TOTAL NUMBER OF ROUNDS REQUIRED.
      DO 6700 I=1,2
      DO 6600 J=1,2
      R(I,J)=G(I,J)*F(I,J)
      R1=AINT(R(I,J))
      R2=R(I,J)-R1
      IF(R2 .EQ. 0.) GO TO 6600
      R(I,J)=R1+1
 6600 CONTINUE
 6700 CONTINUE
      IF(D .EQ. YES)  GO TO 6730
      WRITE(6,64500) WLNGTH(K)
      WRITE(6,10200)
 6730 CONTINUE
      WRITE(6,61000)
      WRITE(6,61500) X0
      WRITE(6,62000) T2
      WRITE(6,10200)
      WRITE(6,62500)
      WRITE(6,63000) G(1,1),D1(1,P0),R(1,1)
      WRITE(6,63500) G(2,1),E(1,P0),R(2,1)
      WRITE(6,10200)
      WRITE(6,64000)
      WRITE(6,61500) X0
      WRITE(6,62000) T2
      WRITE(6,10200)
      WRITE(6,62500)
      WRITE(6,63000) G(1,2),D1(2,P0),R(1,2)
      WRITE(6,63500) G(2,2),E(2,P0),R(2,2)
      GO TO 6790
 6750 CONTINUE
      IF(D .EQ. YES)  GO TO 6780
      WRITE(6,64500) WLNGTH(K)
      WRITE(6,10200)
 6780 CONTINUE
      WRITE(6,65000)
 6790 CONTINUE
      WRITE(6,10200)
 6800 CONTINUE
 6900 CONTINUE
      WRITE(6,10000)
      RETURN
C*FORMAT STATEMENTS.
10000 FORMAT(1H1)
10100 FORMAT(1H0)
10200 FORMAT(1H )
12000 FORMAT(F10.0)
60000 FORMAT(4X,23HMUNITIONS EXPENDITURES:)
60500 FORMAT(31H TIME SMOKE REQUIRED - MINUTES?)
61000 FORMAT(4X,31HVOLUME OF FIRE - HC SMOKESCREEN)
```

```
61500 FORMAT(7X,28HSCREEN LENGTH    - METERS  = ,F8.2)
62000 FORMAT(7X,28HSCREEN DURATION - MINUTES = ,F8.2)
62500 FORMAT(15X,4HGUNS,6X,10HROUNDS/MIN,5X,12HTOTAL ROUNDS)
63000 FORMAT(7X,3H105,3X,F6.2,10X,F6.2,11X,F6.2)
63500 FORMAT(7X,3H155,3X,F6.2,10X,F6.2,11X,F6.2)
64000 FORMAT(4X,31HVOLUME OF FIRE - WP SMOKESCREEN)
64500 FORMAT(4X,A4,13H MICROMETERS:)
65000 FORMAT(4X,49HSMOKE NOT REQUIRED DUE TO ATMOSPHERIC CONDITIONS.)
      END
```

BASIC

GLOSSARY OF MNEMONICS

CO	Ceiling - hundreds of feet
C1	Cloud cover - per cent
VO	Visibility - miles
TO	Temperature degrees F
T1	Dew Point - degrees F
DO	Wind direction - tens of degrees
SO	Wind Speed - knots
PO	Atmospheric stability category
MO	Mixing depth height - meters
RO	Relative humidity - percent
XO	Total distance to be smoked - meters
T2	Time smoke required - minutes
Y	Average roughness element - centimeters
Z	Roughness length - centimeters
P(7,9)	Table of stability categories (depending upon solar altitude and wind speed)
T(5,4)	Table of transmittances owing to water vapor, haze/for, rain and smoke for 0.55, 1.06, 2.3, 3.8, and 10.6 micrometers
C(5,4)	Table of smoke concentration values for fog oil, HC, FS, and WP for 0.55, 1.06, 2.3, 3.8 and 10.6 micrometers
B(5)	Error function absorption coefficients
G(5)	Scale height for Mie scattering
H(5)	Haze and fog attenuation coefficients
R(5)	Rain attenuation coefficients
D(4,3)	Table of coefficients used to calculate smoke concentrations using the calculated transmittance values of 0.55, 1.06 2.3, 3.8, and 10.6 micrometers
Q(5,4)	Smoke source strength values for fog oil, HC, FS, and WP for 0.55, 1.06, 2.3, 3.8 and 10.6 micrometers
A(6)	Coefficients to compute σy continuous source
S(6,4)	Coefficients of the roughness correction factor used in calculating σz for the various roughness lengths
Y1-Y4	Yield factors for fog oil, HC, FS, and WP
R(2,2)	Total number of rounds required to maintain smoke screen
G(2,2)	Number of guns
F(2,2)	Number for rounds per gun
H(2,2)	Unit (per gun) source strength
A(2,2)	Smoke build-up time
B(2,6)	Munition average burn time
D(2.6)	Rate of fire vs stability category for 105 Howitzer
E(2.6)	Rate of fire vs stability category for 155 Howitzer
W(2,2)	Total time for munition replenishment
I$(3)	Met observation station identifier
O$(6)	Stability category indicator
A$(21)	Wavelength indicator
P	Percipitation indicator
D	Demo indicator

```
10 COM D,CO,C1,VO,P,TO,T1,DO,SO,Y,PO,RO,T[5,4],C[5,4],XO,Q[5,4]
20 REM KWIK:  METEOROLOGICAL INPUTS AND METEOROLOGICAL CALCULATIONS.
30 DIM I$[3],P[7,9],Q$[6]
40 FIXED 2
50 PRINT
60 PRINT
70 PRINT "KWIK SMOKE PROGRAM"
80 PRINT
90 PRINT
100 DISP "IS THIS A DEMO - 1=YES O=NO";
110 INPUT D
120 DISP "MET SITE ID";
130 INPUT I$
140 DISP "LATITUDE OF MET SITE - DEG";
150 INPUT LO
160 DISP "LONGITUDE OF MET SITE - DEG";
170 INPUT L1
180 DISP "ALTITUDE OF MET SITE-KILOMETERS";
190 INPUT ZO
200 DISP "JULIAN DATE OF MET OBSERVATION";
210 INPUT JO
220 DISP "ZULU TIME OF MET OBSERVATION-HR";
230 INPUT HO
240 PRINT "    MET SITE:"
250 PRINT
260 PRINT "        ID                    =  ";I$
270 PRINT "        LATITUDE     - DEG  = ";LO
280 PRINT "        LONGITUDE    - DEG  = ";L1
290 PRINT "        ALTITUDE     - KM   = ";ZO
300 PRINT
310 PRINT "        JULIAN DATE - DAY  = ";JO
320 PRINT "        ZULU TIME   - HOUR = ";HO
330 PRINT
340 PRINT
350 DISP "CEILING - HUNDREDS OF FEET";
360 INPUT CO
370 CO=(CO*100)*0.3048
380 DISP "CLOUD COVER - PERCENT";
390 INPUT C1
400 DISP "VISIBILITY - MILES";
410 INPUT VO
420 VO=VO*1.61
430 DISP "PRECIPITATION - 1=YES O=NO";
440 INPUT P
450 DISP "TEMPERATURE - DEG F";
460 INPUT TO
470 TO=(5/9)*(TO-32)
480 DISP "DEW POINT - DEG F";
490 INPUT T1
500 T1=(5/9)*(T1-32)
```

```
510 DISP "WIND DIRECTION - TENS OF DEGS";
520 INPUT DO
530 DO=DO*10
540 DISP "WIND SPEED - KNOTS";
550 INPUT SO
560 DISP "AVE ROUGHNESS ELEMENT - CM";
570 INPUT Y
580 PRINT "    METEOROLOGICAL INPUTS:"
590 PRINT
600 PRINT "       CEILING                  - METERS      = ";CO
610 PRINT "       CLOUD COVER              - PERCENT     = ";C1
620 PRINT "       VISIBILITY               - KILOMETERS  = ";VO
630 PRINT "       PRECIPITATION                          = ";P
640 PRINT "       TEMPERATURE              - DEG C       = ";TO
650 PRINT "       DEWPOINT                 - DEG C       = ";T1
660 PRINT "       WIND DIRECTION           - DEG         = ";DO
670 PRINT "       WIND SPEED               - KNOTS       = ";SO
680 PRINT "       AVE ROUGHNESS ELEMENT    - CM          = ";Y
690 PRINT
700 PRINT
710 FOR J=1 TO 9
720 FOR I=1 TO 7
730 READ P[I,J]
740 NEXT I
750 NEXT J
760 READ O$[1]
770 IF C1#100 THEN 820
780 IF CO>2133.6042 THEN 820
790 I1=0
800 I2=0
810 GOTO 1540
820 REM CALCULATE ANGULAR FRACTION OF A YEAR FOR A GIVEN JULIAN DATE (AO).
830 R9=PI/180
840 D9=180/PI
850 LO=LO*R9
860 AO=((JO-1)*360)/365.242
870 REM CALCULATE SOLAR DECLINATION ANGLE (A4).
880 A1=AO*R9
890 A2=279.9348+AO
900 A2=A2+(1.914827*SIN(A1))-(0.079525*COS(A1))
910 A2=A2+(0.019938*SIN(2*A1))-(0.00162*COS(2*A1))
920 A2=A2*R9
930 A3=23.4438*R9
940 A4=SIN(A3)*SIN(A2)
950 A4=ATN(A4/SQR(1-A4*A4+1E-99))
960 REM CALCULATE THE TIME OF MERIDIAN PASSAGE - TRUE SOLAR NOON (A5).
970 A5=12+(0.12357*SIN(A1))-(0.004289*COS(A1))
980 A5=A5+(0.153809*SIN(2*A1))+(0.060783*COS(2*A1))
990 REM CALCULATE SOLAR HOUR ANGLE (A6).
1000 A6=15*(HO-A5)-L1
```

```
1010 A6=A6*R9
1020 REM CALCULATE SOLAR ALTITUDE (A7).
1030 A7=SIN(LO)*SIN(A4)+COS(LO)*COS(A4)*COS(A6)
1040 A7=ATN(A7/SQR(1-A7*A7+1E-99))
1050 REM CALCULATE TIME OF SUNRISE AND SUNSET (BO,B1).
1060 A8=-1.76459*ZO^0.40795
1070 A8=A8*R9
1080 A9=(SIN(A8)-(SIN(LO)*SIN(A4)))/(COS(LO)*COS(A4))
1090 A9=ATN(SQR(1-A9*A9)/(A9+1E-99))+2*ATN1E+99*(A9<0)
1100 A9=A9*D9
1110 A9=A9*(24/360)
1120 BO=(L1/15)+A5-A9
1130 B1=(L1/15)+A5+A9
1140 IF B1 <= 24 THEN 1160
1150 B1=B1-24
1160 A7=A7*D9
1170 REM CALCULATE INSOLATION CLASS NUMBER.
1180 I2=0
1190 IF A7 <= 60 THEN 1220
1200 I2=4
1210 GOTO 1300
1220 IF A7 <= 35 THEN 1250
1230 I2=3
1240 GOTO 1300
1250 IF A7 <= 15 THEN 1280
1260 I2=2
1270 GOTO 1300
1280 IF A7 <= 0 THEN 1490
1290 I2=1
1300 REM CALCULATE NET RADIATION INDEX FOR DAYTIME.
1310 I3=0
1320 IF C1>50 THEN 1350
1330 I3=I2
1340 GOTO 1430
1350 IF CO >= 2133.6042 THEN 1380
1360 I3=I2-2
1370 GOTO 1430
1380 IF CO >= 4876.8096 THEN 1410
1390 I3=I2-1
1400 GOTO 1430
1410 IF C1#100 THEN 1430
1420 I3=I2-1
1430 IF I3#0 THEN 1450
1440 I3=I2
1450 IF I3>1 THEN 1470
1460 I3=1
1470 I1=I3
1480 GOTO 1540
1490 REM CALCULATE NET RADIATION INDEX FOR NIGHTTIME.
1500 IF C1>40 THEN 1530
```

```
1510 I1=-2
1520 GOTO 1540
1530 I1=-1
1540 REM CALCULATE PASQUILL STABILITY CATEGORY.
1550 I4=0
1560 I5=0
1570 IF I1#4 THEN 1590
1580 I4=1
1590 IF I1#3 THEN 1610
1600 I4=2
1610 IF I1#2 THEN 1630
1620 I4=3
1630 IF I1#1 THEN 1650
1640 I4=4
1650 IF I1#0 THEN 1670
1660 I4=5
1670 IF I1#-1 THEN 1690
1680 I4=6
1690 IF I1#-2 THEN 1710
1700 I4=7
1710 IF SO >= 2 THEN 1730
1720 I5=1
1730 IF SO >= 4 THEN 1760
1740 I5=2
1750 GOTO 1950
1760 IF SO >= 6 THEN 1790
1770 I5=3
1780 GOTO 1950
1790 IF SO >= 7 THEN 1820
1800 I5=4
1810 GOTO 1950
1820 IF SO >= 8 THEN 1850
1830 I5=5
1840 GOTO 1950
1850 IF SO >= 10 THEN 1880
1860 I5=6
1870 GOTO 1950
1880 IF SO >= 11 THEN 1910
1890 I5=7
1900 GOTO 1950
1910 IF SO >= 12 THEN 1940
1920 I5=8
1930 GOTO 1950
1940 I5=9
1950 PO=P[I4,I5]
1960 REM CALCULATE MIXING DEPTH HEIGHT.
1970 MO=(6-PO)*121*(TO-T1)/6+(PO*0.087*(SO+0.5))/(12*8.237E-05*5.809)
1980 REM CALCULATE RELATIVE HUMIDITY.
1990 IF TO>0 THEN 2030
2000 AO=9.5
```

```
2010 B0=265.5
2020 GOTO 2050
2030 A0=7.5
2040 B0=237.3
2050 IF T1>0 THEN 2090
2060 A1=9.5
2070 B1=265.5
2080 GOTO 2110
2090 A1=7.5
2100 B1=237.3
2110 E0=6.11*10^((A0*T0)/(B0+T0))
2120 E1=6.11*10^((A1*T1)/(B1+T1))
2130 R0=(E1/E0)*100
2140 PRINT "     METEOROLOGICAL CALCULATIONS:"
2150 PRINT
2160 PRINT "          PASQUILL STABILITY CATEGORY =  ";Q$[P0,P0]
2170 PRINT "          RELATIVE HUMIDITY           =  ";R0
2180 PRINT
2190 PRINT
2200 DISP "DONE - LINK 1"
2210 REM PASQUILL STABILITY CATEGORY DATA.
2220 DATA 1,1,2,3,4,6,6
2230 DATA 1,2,2,3,4,6,6
2240 DATA 1,2,3,4,4,5,6
2250 DATA 2,2,3,4,4,5,6
2260 DATA 2,2,3,4,4,4,5
2270 DATA 2,3,3,4,4,4,5
2280 DATA 3,3,4,4,4,4,5
2290 DATA 3,3,4,4,4,4,4
2300 DATA 3,4,4,4,4,4,4
2310 DATA "ABCDEF"
2320 END
```

```
10 COM D,C0,C1,V0,P,T0,T1,D0,S0,Y,P0,R0,T[5,4],C[5,4],X0,Q[5,4]
20 REM KWIK:  ATMOSPHERIC OPTICS AND SMOKE CONCENTRATION CALCULATIONS
30 DIM B[5],G[5],H[5],R[5],A$[21],D[4,3]
40 FIXED 2
50 IF D=1 THEN 80
60 PRINT "     ATMOSPHERIC OPTICS AND SMOKE CONCENTRATION CALCULATIONS:"
70 PRINT
80 FOR I=1 TO 5
90 READ B[I],G[I]
100 NEXT I
110 V1=LOG(V0)
120 V2=V1*V1
130 V3=V2*V1
140 H[1]=1.5551-(0.9811*V1)-(0.0197*V2)+(0.0041*V3)
150 H[1]=EXP(H[1])
160 H[2]=1.5551-(0.9811*V1)-(0.0197*V2)+(0.0041*V3)
170 H[2]=EXP(H[2])
180 H[3]=1.4491-(1.0044*V1)-(0.012*V2)+(0.0032*V3)
190 H[3]=EXP(H[3])
200 H[4]=1.2394-(1.0436*V1)+(0.0099*V2)-(0.0016*V3)
210 H[4]=EXP(H[4])
220 H[5]=1.5176-(1.7147*V1)+(0.0001*V2)+(0.0428*V3)
230 H[5]=EXP(H[5])
240 R[1]=1.3306-(0.8825*V1)-(0.0753*V2)+(0.0129*V3)
250 R[1]=EXP(R[1])
260 R[2]=1.4098-(0.9865*V1)-(0.014*V2)+(2.3E-03*V3)
270 R[2]=EXP(R[2])
280 R[3]=1.5497-(0.8696*V1)-(0.1084*V2)+(0.0231*V3)
290 R[3]=EXP(R[3])
300 R[4]=1.5556-(0.9013*V1)-(0.0773*V2)+(0.0173*V3)
310 R[4]=EXP(R[4])
320 R[5]=1.5928-(0.9396*V1)-(0.0627*V2)+(0.0168*V3)
330 R[5]=EXP(R[5])
340 H0=0
350 DISP "SLANT RANGE TO TARGET - METERS";
360 INPUT H3
370 DISP "ANGLE OF SIGHT TO TARGET - DEG";
380 INPUT S
390 IF D=1 THEN 430
400 PRINT "          SLANT RANGE TO TARGET          - METERS = ";H3
410 PRINT "          ANGLE OF SIGHT TO TARGET       - DEG    = ";S
420 PRINT
430 H3=H3/1000
440 IF S >= 0 THEN 460
450 S=-S
460 S=S*(PI/180)
470 H1=SIN(S)*H3
480 H2=COS(S)*H3
490 S=SIN(S)
500 H4=0
```

```
510 IF S=0 THEN 540
520 H4=1/S
530 REM CALCULATE PRECIPITABLE WATER.
540 W=0.4477+(0.0328*T1)+(1.2E-03*T1*T1)+(1.84E-05*T1*T1*T1)
550 IF D=1 THEN 570
560 PRINT "        PRECIPITABLE WATER                  - CM/KM = ";W
570 REM CALCULATE AMOUNT OF WATER VAPOR IN PATH.
580 DEF FNA(A)=EXP(-S*A/2)
590 L0=H3
600 L1=H0
610 L2=L0
620 L3=0.5*(L1+L2)
630 L4=L2-L1
640 L5=0.2886751*L4
650 W0=0.5*L4*(FNA(L3+L5)+FNA(L3-L5))
660 W1=W*W0
670 IF D=1 THEN 690
680 PRINT "        AMOUNT OF WATER VAPOR IN PATH  - CM     = ";W1
690 REM CALCULATE TRANSMITTANCES FOR 0.55,1.06,2.3,3.8,10.6 MICRON WAVELENGTHS.
700 FOR J=1 TO 5
710 READ A$
720 IF D=1 THEN 760
730 PRINT
740 PRINT A$
750 PRINT
760 REM CALCULATE TRANSMITTANCE OWING TO ABSORPTION BY WATER VAPOR.
770 IF J#5 THEN 800
780 T[J,1]=EXP(-0.0681*W)
790 GOTO 900
800 DEF FNB(B)=EXP(-B^2)
810 L0=(B[J]*SQR(W1*PI)/2)
820 L1=H0
830 L2=L0
840 L3=0.5*(L1+L2)
850 L4=L2-L1
860 L5=0.2886751*L4
870 T2=0.5*L4*(FNB(L3+L5)+FNB(L3-L5))
880 T[J,1]=(2/SQR(PI))*T2
890 T[J,1]=1-T[J,1]
900 IF D=1 THEN 920
910 PRINT "        TRANSMITTANCE OWING TO ATTENUATION BY:  WATER VAPOR= ";T[J,1]
920 REM CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY HAZE AND FOG.
930 IF P=0 THEN 960
940 T[J,2]=1
950 GOTO 1250
960 IF V0 >= G[J] THEN 1170
970 DEF FNC(C)=EXP(+C*S*LOG(0.1/H[J]))
980 L0=H4
990 L1=H0
1000 L2=L0
```

```
1010 L3=0.5*(L1+L2)
1020 L4=L2-L1
1030 L5=0.2886751*L4
1040 T3=0.5*L4*(FNC(L3+L5)+FNC(L3-L5))
1050 T4=EXP(-H[J]*T3)
1060 DEF FND(D)=EXP(-D*S/4.1)
1070 L0=H3-H4
1080 L1=H4
1090 L2=H4+L0
1100 L3=0.5*(L1+L2)
1110 L4=L2-L1
1120 L5=0.2886751*L4
1130 T5=0.5*L4*(FND(L3+L5)+FND(L3-L5))
1140 T6=EXP(-0.128*T5)
1150 T[J,2]=T4*T6
1160 GOTO 1250
1170 L0=H3
1180 L1=H0
1190 L2=L0
1200 L3=0.5*(L1+L2)
1210 L4=L2-L1
1220 L5=0.2886751*L4
1230 T7=0.5*L4*(FND(L3+L5)+FND(L3-L5))
1240 T[J,2]=EXP(-H[J]*T7)
1250 IF D=1 THEN 1270
1260 PRINT "                                        HAZE/FOG   = ";T[J,2]
1270 REM CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY RAIN.
1280 IF P=1 THEN 1310
1290 T[J,3]=1
1300 GOTO 1330
1310 IF VO>20 THEN 1290
1320 T[J,3]=EXP(-H3*R[J])
1330 IF D=1 THEN 1350
1340 PRINT "                                        RAIN       = ";T[J,3]
1350 REM CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY SMOKE.
1360 T[J,4]=0.02/(T[J,1]*T[J,2]*T[J,3])
1370 IF T[J,4] <= 1 THEN 1390
1380 T[J,4]=1
1390 IF D=1 THEN 1420
1400 PRINT "                                        SMOKE      = ";T[J,4]
1410 PRINT
1420 REM CALCULATE SMOKE CONCENTRATION.
1430 FOR K=1 TO 4
1440 READ D[K,1],D[K,2],D[K,3]
1450 NEXT K
1460 IF T[J,4]#1 THEN 1510
1470 FOR I=1 TO 4
1480 C[J,I]=0
1490 NEXT I
1500 GOTO 1570
```

```
1510 T8=LOG(T[J,4])
1520 T9=T8*T8
1530 FOR K=1 TO 4
1540 C[J,K]=D[K,1]+D[K,2]*T8+D[K,3]*T9
1550 NEXT K
1560 IF D=1 THEN 1610
1570 PRINT "          SMOKE CONCENTRATION:  FOG OIL - GM/SQ M = ";C[J,1]
1580 PRINT "                                HC      - GM/SQ M = ";C[J,2]
1590 PRINT "                                FS      - GM/SQ M = ";C[J,3]
1600 PRINT "                                WP      - GM/SQ M = ";C[J,4]
1610 NEXT J
1620 IF D=1 THEN 1650
1630 PRINT
1640 PRINT
1650 DISP "DONE - LINK 2"
1660 DATA 0.118,26.7
1670 DATA 0.22,13
1680 DATA 0.14,5.3
1690 DATA 0.55,5.1
1700 DATA 0,5
1710 DATA "     0.55 MICROMETERS:"
1720 DATA 0.0093,-0.3428,-0.0009
1730 DATA 0.0119,-0.2747,-0.0013
1740 DATA 0.0142,-0.111,0.00004
1750 DATA 0.0055,-0.1541,-0.0004
1760 DATA "     1.06 MICROMETERS:"
1770 DATA 0.0093,-0.3428,-0.0009
1780 DATA 0.0119,-0.2747,-0.0013
1790 DATA 0.0142,-0.111,0.00004
1800 DATA 0.0055,-0.1541,-0.0004
1810 DATA "     2.30 MICROMETERS:"
1820 DATA 0.0093,-0.3428,-0.0009
1830 DATA 0.0119,-0.2747,-0.0013
1840 DATA 0.0142,-0.111,0.00004
1850 DATA 0.0055,-0.1541,-0.0004
1860 DATA "     3.80 MICROMETERS:"
1870 DATA 0.0093,-0.3428,-0.0009
1880 DATA 0.0119,-0.2747,-0.0013
1890 DATA 0.0142,-0.111,0.00004
1900 DATA 0.0055,-0.1541,-0.0004
1910 DATA "     10.6 MICROMETERS:"
1920 DATA 0.0093,-0.3428,-0.0009
1930 DATA 0.0119,-0.2747,-0.0013
1940 DATA 0.0142,-0.111,0.00004
1950 DATA 0.0055,-0.1541,-0.0004
1960 END
```

```
10 COM D,CO,C1,VO,P,TO,T1,DO,SO,Y,PO,RO,T[5,4],C[5,4],XO,Q[5,4]
20 REM KWIK:  ATMOSPHERIC DIFFUSION AND SMOKE SOURCE STRENGTH CALCULATIONS.
30 DIM S[6,4],A[6]
40 DIM A$[21]
50 FIXED 2
60 IF D=1 THEN 90
70 PRINT "    ATMOSPHERIC DIFFUSION AND SMOKE SOURCE STRENGTH CALCULATIONS:"
80 PRINT
90 DISP "TOTAL DISTANCE TO BE SMOKED - M";
100 INPUT XO
110 DISP "RELEASE HEIGHT OF SMOKE SOURCE";
120 INPUT HO
130 DISP "MEAN HEIGHT OF TARGET - METERS";
140 INPUT ZO
150 DISP "DIRECTION OF LINE OF SIGHT-DEG";
160 INPUT AO
170 IF D=1 THEN 220
180 PRINT "        TOTAL DISTANCE TO BE SMOKED                - METERS = ";XO
190 PRINT "        RELEASE HEIGHT OF SMOKE SOURCE (AGL) - METERS = ";HO
200 PRINT "        MEAN HEIGHT OF TARGET                      - METERS = ";ZO
210 PRINT "        DIRECTION OF LINE OF SIGHT TO TARGET - DEG    = ";AO
220 REM DIFFUSION CALCULATIONS FOR CONTINUOUS SOURCE.
230 FOR I=1 TO 6
240 READ A[I]
250 NEXT I
260 FOR I=1 TO 6
270 FOR J=1 TO 4
280 READ S[I,J]
290 NEXT J
300 NEXT I
310 A1=-1.24+1.19*LGT(Y)
320 Z=10^A1
330 B1=LOG(Z)
340 B2=LOG(Z)^2
350 B3=LOG(Z)^3
360 B4=LOG(Z)^4
370 B5=LOG(Z)^5
380 B6=0.444685869+0.294049265*B1-0.237213914*B2
390 B7=0.155349504*B3-0.032015723*B4+2.15168E-03*B5
400 D1=B6+B7
410 D1=EXP(D1)
420 B6=-1.298283909-1.006186784*B1+1.485094886*B2
430 B7=-0.774136725*B3+0.156559355*B4-0.010823351*B5
440 D2=B6+B7
450 D2=EXP(D2)-0.225
460 IF Z>9.999999 THEN 500
470 B6=5.77267E-04+2.31943E-05*B1+3.71041E-05*B2
480 B7=-8.40602E-06*B3+1.3421E-07*B4+2.55131E-08*B5
490 GOTO 560
500 IF Z>40 THEN 540
```

```
510 B6=-11.56134901+2.148242814*B1-0.156210817*B2
520 B7=7.03582E-03*B3-1.47353E-04*B4+1.18256E-06*B5
530 GOTO 560
540 B6=1108.366588-103.5495836*B1+2.424499256*B2
550 B7=-0.014584773*B3+4.34517E-05*B4-4.69556E-08*B5
560 D3=B6+B7
570 B6=0.500775609+1.092614788*B1-1.573065836*B2
580 B7=0.724276579*B3-0.140820904*B4+9.61621E-03*B5
590 D4=B6+B7
600 D4=EXP(D4)-1.2
610 IF Z>10 THEN 640
620 B1=LOG(D1*XO^D2*1/(1+D3*XO^D4))
630 GOTO 650
640 B1=LOG(D1*XO^D2*(1+1/(D3*XO^D4)))
650 B2=S[PO,1]*XO^S[PO,2]/(1+S[PO,3]*XO^S[PO,4])
660 S2=B1*B2
670 S1=A[PO]*XO^0.9
680 IF D=1 THEN 740
690 PRINT
700 PRINT "    CONTINUOUS SOURCE:"
710 PRINT
720 PRINT "        SIGMA Y - METERS = ";S1
730 PRINT "        SIGMA Z - METERS = ";S2
740 REM SMOKE SOURCE STRENGTH CALCULATIONS FOR CONTINUOUS SOURCE.
750 A2=ABS(AO-DO)*(PI/180)
760 IF SO#0 THEN 780
770 SO=1
780 S3=SO*0.515
790 QO=S2*S3*SQR(PI)/SQR(2)*EXP(-0.5*((ZO-HO)/S2)^2)
800 R2=SQR(3.3124/(6.76*SIN(A2)*SIN(A2)+0.49*COS(A2)*COS(A2)))
810 Y2=0.9337+(0.0369*RO)-(7E-04*RO*RO)+(6.11E-06*RO*RO*RO)
820 Y3=1.3775+(0.09868*RO)-(1.8E-03*RO*RO)+(1.56E-05*RO*RO*RO)
830 QO=QO*R2
840 Q1=QO/Y2
850 Q2=QO/Y3
860 FOR I=1 TO 5
870 Q[I,1]=C[I,1]*QO
880 Q[I,2]=C[I,2]*Q1
890 Q[I,3]=C[I,3]*Q2
900 READ A$
910 IF D=1 THEN 980
920 PRINT
930 PRINT A$
940 PRINT
950 PRINT "        SOURCE STRENGTH:  FOG OIL - GMS/SEC = ";Q[I,1]
960 PRINT "                          HC      - GMS/SEC = ";Q[I,2]
970 PRINT "                          FS      - GMS/SEC = ";Q[I,3]
980 NEXT I
990 REM DIFFUSION CALCULATIONS FOR QUASI-INSTANTANEOUS SOURCE.
1000 RESTORE 1350
```

```
1010 S1=2/3*S1
1020 S2=2/3*S2
1030 IF D=1 THEN 1090
1040 PRINT
1050 PRINT "     QUASI-INSTANTANEOUS SOURCE:"
1060 PRINT
1070 PRINT "        SIGMA Y - METERS = ";S1
1080 PRINT "        SIGMA Z - METERS = ";S2
1090 REM SMOKE SOURCE STRENGTH CALCULATIONS FOR QUASI-INSTANTANEOUS SOURCE.
1100 QO=(S1*S2*PI)/EXP(-(ZO*ZO-HO*HO)/(2*S2*S2))
1110 Y4=3.2469+(0.0774*RO)-(1.6E-03*RO*RO)+(1.73E-05*RO*RO*RO)
1120 QO=(QO/Y4)*10
1130 FOR I=1 TO 5
1140 Q[I,4]=C[I,4]*QO
1150 READ A$
1160 IF D=1 THEN 1210
1170 PRINT
1180 PRINT A$
1190 PRINT
1200 PRINT "        SOURCE STRENGTH:  WP - GMS/SEC = ";Q[I,4]
1210 NEXT I
1220 IF D=1 THEN 1250
1230 PRINT
1240 PRINT
1250 DISP "DONE - LINK 3"
1260 REM DATA USED TO CALCULATE SIGMA Y FOR CONTINUOUS SOURCE.
1270 DATA 0.4,0.32,0.22,0.144,0.102,0.076
1280 REM DATA USED TO CALCULATE SIGMA Z FOR CONTINUOUS SOURCE.
1290 DATA 0.112,1.06,5.38E-04,0.815
1300 DATA 0.13,0.95,6,52E-04,0.75
1310 DATA 0.112,0.92,9.05E-04,0.718
1320 DATA 0.098,0.889,1.35E-03,0.688
1330 DATA 0.0609,0.895,1.96E-03,0.684
1340 DATA 0.0638,0.783,1.36E-03,0.672
1350 DATA "    0.55 MICROMETERS:"
1360 DATA "    1.06 MICROMETERS:"
1370 DATA "    2.30 MICROMETERS:"
1380 DATA "    3.80 MICROMETERS:"
1390 DATA "    10.6 MICROMETERS:"
1400 END
```

```
10 COM D,CO,C1,VO,P,TO,T1,DO,SO,Y,PO,RO,T[5,4],C[5,4],XO,Q[5,4]
20 REM KWIK:  MUNITION EXPENDITURES.
30 DIM G[2,2],H[2,2],W[2,2],A[2,2],B[2,2],D[2,6],E[2,6],F[2,2],R[2,2]
40 DIM A$[21]
50 FIXED 2
70 PRINT "    MUNITION EXPENDITURES:"
80 PRINT
90 READ H[1,1],H[1,2],H[2,1],H[2,2]
100 READ A[1,1],A[1,2],A[2,1],A[2,2]
110 READ B[1,1],B[1,2],B[2,1],B[2,2]
120 READ D[1,1],D[1,2],D[1,3],D[1,4],D[1,5],D[1,6]
130 READ D[2,1],D[2,2],D[2,3],D[2,4],D[2,5],D[2,6]
140 READ E[1,1],E[1,2],E[1,3],E[1,4],E[1,5],E[1,6]
150 READ E[2,1],E[2,2],E[2,3],E[2,4],E[2,5],E[2,6]
160 DISP "TIME SMOKE REQUIRED - MINUTES";
170 INPUT T2
180 FOR K=1 TO 5
190 IF K=1 THEN 210
200 IF D=1 THEN 830
210 IF T[K,4]=1 THEN 760
220 REM CALCULATE NUMBER OF GUNS REQUIRED.
230 G[1,1]=Q[K,2]/H[1,1]
240 G[1,2]=Q[K,4]/H[1,2]
250 G[2,1]=Q[K,2]/H[2,1]
260 G[2,2]=Q[K,4]/H[2,2]
270 FOR I=1 TO 2
280 FOR J=1 TO 2
290 GO=INT(G[I,J])
300 G1=G[I,J]-GO
310 IF G1=0 THEN 330
320 G[I,J]=GO+1
330 NEXT J
340 NEXT I
350 REM CALCULATE TOTAL TIME FOR REPLENISHMENT.
360 FOR I=1 TO 2
370 FOR J=1 TO 2
380 W[I,J]=T2+A[I,J]-B[I,J]
390 NEXT J
400 NEXT I
410 REM CALCULATE RATE OF FIRE.
420 FOR J=1 TO 2
430 F[1,J]=W[1,J]*D[J,PO]+1
440 F[2,J]=W[2,J]*E[J,PO]+1
450 NEXT J
460 REM CALCULATE TOTAL NUMBER OF ROUNDS REQUIRED.
470 FOR I=1 TO 2
480 FOR J=1 TO 2
490 R[I,J]=G[I,J]*F[I,J]
500 R1=INT(R[I,J])
510 R2=R[I,J]-R1
```

```
520 IF R2=0 THEN 540
530 R[I,J]=R1+1
540 NEXT J
550 NEXT I
560 READ A$
570 IF D=1 THEN 600
580 PRINT A$
590 PRINT
600 PRINT "          VOLUME OF FIRE - HC SMOKESCREEN"
610 PRINT "              SCREEN LENGTH   - METERS  = ";X0
620 PRINT "              SCREEN DURATION - MINUTES = ";T2
630 PRINT
640 PRINT "                      GUNS         ROUNDS/MIN      TOTAL ROUNDS"
650 PRINT "              105  ";G[1,1];"         ";D[1,P0];"           ";R[1,1]
660 PRINT "              155  ";G[2,1];"         ";E[1,P0];"           ";R[2,1]
670 PRINT
680 PRINT "          VOLUME OF FIRE - WP SMOKESCREEN"
690 PRINT "              SCREEN LENGTH   - METERS  = ";X0
700 PRINT "              SCREEN DURATION - MINUTES = ";T2
710 PRINT
720 PRINT "                      GUNS         ROUNDS/MIN      TOTAL ROUNDS"
730 PRINT "              105  ";G[1,2];"         ";D[2,P0];"           ";R[1,2]
740 PRINT "              155  ";G[2,2];"         ";E[2,P0];"           ";R[2,2]
750 GOTO 810
760 READ A$
770 IF D=1 THEN 800
780 PRINT A$
790 PRINT
800 PRINT "      SMOKE NOT REQUIRED DUE TO ATMOSPHERIC CONDITIONS."
810 PRINT
820 NEXT K
830 PRINT
840 PRINT
850 DISP "DONE"
860 REM UNIT(PER GUN) SOURCE STRENGTHS.
870 DATA 18.9,1737.3,48.8,7076.2
880 REM TIME FOR BUILDUP.
890 DATA 1,0.5,1,0.5
900 REM AVERAGE BURN TIME.
910 DATA 3,0.0167,4,0.0167
920 REM RATE OF FIRE VS. STABILITY CATEGORY.
930 DATA 6,4,3,2,1,1
940 DATA 0,0,6,4,1.5,1
950 DATA 3,2,1.5,1,0.5,0.333
960 DATA 0,0,3,2,0.5,0.333
970 DATA "     0.55 MICROMETERS:"
980 DATA "     1.06 MICROMETERS:"
990 DATA "     2.30 MICROMETERS:"
1000 DATA "     3.80 MICROMETERS:"
1010 DATA "     10.6 MICROMETERS:"
1020 END
```

HPL

GLOSSARY OF MNEMONICS

A	Ceiling - hundreds of feet
B	Cloud cover - per cent
C	Visibility - miles
D	Temperature - degrees F
E	Dew Point - degrees F
F	Wind dirction - tens of degrees
G	Wind Speed - knots
H	Atmospheric stability category
P	Mixing depth height - meters
Q	Relative humidity - percent
R	Total distance to be smoked - meters
T	Time smoke required - minutes
Y	Average roughness element - centimeters
Z	Roughness length - centimeters
A(7,9)	Table of stability categories (depending upon solar altitude and wind speed)
B(5,4)	Table of transmittances owing to water vapor, haze/fog. rain and smoke for 0.55, 1.06, 2.3, 3.8, and 10.6 micrometers
C(5,4)	Table of smoke concentration values for fog oil, HC, FS and WP for 0.55, 1.06, 2.3, 3.8, and 10.6 micrometers
D(5)	Error function absorption coefficients
E(5)	Scale height for Mie scattering
F(5)	Haze and fog attenuation coefficients
G(5)	Rain attenuation coefficients
H(3,4,5)	Table of coefficients used to calculate smoke concentrations using the calculated transmittance values for 0.55, 1.06, 2.3, 3.8, and 10.6 micrometers
I(5,4)	Smoke source strength values for fog oil, HC, FS, and WP for 0.55, 1.06, 2.3, 3.8, and 10.6 micrometers
J(6)	Coefficients to compute σy - continuous source
K(6,4)	Coefficients of the roughness correction factor used in calculating σz for the various roughness lengths
M(4)	Yield factors for fog oil, HC, FS, and WP
P(2,2)	Total number of rounds required to maintain smoke screen
Q(2,2)	Number of guns
R(2,2)	Number of rounds per gun
S(2,2)	Unit (per gun) source strength
T(2,2)	Smoke build-up time
U(2,2)	Munition average burn time
V(2,6)	Rate of fire vs stability category for 105 Howitzer
W(2,6)	Rate of fire vs stability category for 155 Howitzer
X(2,2)	Total time for munition replenishment
A$(3)	Met observation station identifier
B$(6)	Stability category indicator
C$(80)	Wavelength indicator
D$(3)	Precipitation indicator
E$	Demo indicator

```
1: dim A[7,9],B[5,4],C[5,4],D[5],E[5],F[5],G[5],H[3,4,5],I[5,4]
2: dim J[6],K[6,4],M[4],P[2,2],Q[2,2],R[2,2]
3: dim S[2,2],T[2,2],U[2,2],V[2,6],W[2,6],X[2,2]
4: dim A$[3],B$[6],C$[85],D$[3],E$[3]
5: asgn "KDATA1",1
6: files KDATA1
7: sread 1,A[*],D[*],E[*],H[*],J[*],K[*]
8: sread 1,S[*],T[*],U[*],V[*],W[*]
9: sread 1,B$,C$
10: fmt 2/;wrt 701
11: fmt "KWIK SMOKE PROGRAM";wrt 701
12: fmt /;wrt 701
13: ent "IS THIS A DEMO? YES OR NO",E$
14: ent "MET SITE ID",A$
15: ent "LATITUDE OF MET SITE - DEG",r2
16: ent "LONGITUDE OF MET SITE - DEG",r3
17: ent "ALTITUDE OF MET SITE-KILOMETERS",r4
18: ent "JULIAN DATE OF MET OBSERVATION",r5
19: ent "ZULU TIME OF MET OBSERVATION-HR",r6
20: fmt "      MET SITE:";wrt 701
21: fmt " ";wrt 701
22: fmt "         ID              = ",2x,c3;wrt 701,A$
23: fmt"          LATITUDE  - DEG = ",f6.2;wrt 701,r2
24: fmt"          LONGITUDE - DEG = ",f6.2;wrt 701,r3
25: fmt "         ALTITUDE    KM  = ",2x,f4.2;wrt 701,r4
26: fmt " ";wrt 701
27: fmt "         JULIAN DATE - DAY  = ",f3.0;wrt 701,r5
28: fmt "         ZULU TIME   - HOUR = ",1x,f2.0;wrt 701,r6
29: fmt /;wrt 701
30: ent "CEILING - HUNDREDS OF FEET",A
31: A*100*.3048→A
32: ent "CLOUD COVER - PERCENT",B
33: ent "VISIBILITY - MILES",C
34: C*1.61→C
35: ent "PRECIPITATION - YES OR NO",D$
36: ent "TEMPERATURE - DEG F",D
37: 5/9*(D-32)→D
38: ent "DEW POINT - DEG F",E
39: 5/9*(E-32)→E
40: ent "WIND DIRECTION - TENS OF DEGS",F
41: F*10→F
42: ent "WIND SPEED - KNOTS",G
43: ent "AVE ROUGHNESS ELEMENT - CM",Y
44: fmt "      METEOROLOGICAL INPUTS:";wrt 701
45: fmt " ";wrt 701
46: fmt "         CEILING              - METERS     = ",f8.2;wrt 701,A
47: fmt "         CLOUD COVER          - PERCENT    = ",f8.2;wrt 701,B
48: fmt "         VISIBILITY           - KILOMETERS = ",f8.2;wrt 701,C
49: fmt "         PRECIPITATION                     = ",4x,c3;wrt 701,D$
50: fmt "         TEMPERATURE          - DEG C      = ",f8.2;wrt 701,D
*20242
```

```
51: fmt "        DEWPOINT                  - DEG C       = ",f8.2;wrt 701,E
52: fmt "        WIND DIRECTION            - DEG         = ",f8.2;wrt 701,F
53: fmt "        WIND SPEED                - KNOTS       = ",f8.2;wrt 701,G
54: fmt "        AVE ROUGHNESS ELEMENT     - CM          = ",f8.2;wrt 701,Y
55: fmt /;wrt 701
56: if B#100;gto "K1000"
57: if A>2133.6042;gto "K1000"
58: 0→r0
59: 0→r1
60: gto "K1400"
61: "K1000":
62: fmt "CALCULATE ANGULAR FRACTION OF A YEAR FOR A GIVEN JULIAN DATE"
63: (r5-1)*360/365.242→r9
64: fmt "CALCULATE SOLAR DECLINATION ANGLE"
65: 279.9348+r9→r11
66: r11+1.914827*sin(r9)-.079525*cos(r9)→r11
67: r11+.019938*sin(2*r9)-.00162*cos(2*r9)→r11
68: 23.4438→r12
69: sin(r12)*sin(r11)→r13
70: asn(r13)→r13
71: fmt "CALCULATE TIME OF MERIDIAN PASSAGE - TRUE SOLAR NOON"
72: 12+.12357*sin(r9)-.004289*cos(r9)→r14
73: r14+.153809*sin(2*r9)+.060783*cos(2*r9)→r14
74: fmt "CALCULATE SOLAR HOUR ANGLE"
75: 15*(r6-r14)-r3→r15
76: fmt "CALCULATE SOLAR ALTITUDE"
77: sin(r2)*sin(r13)+cos(r2)*cos(r13)*cos(r15)→r16
78: asn(r16)→r16
79: fmt "CALCULATE TIME OF SUNRISE AND SUNSET"
80: -1.76459*r4^.40795→r17
81: (sin(r17)-sin(r2)*sin(r13))/(cos(r2)*cos(r13))→r18
82: acs(r18)→r18
83: r18*(24/360)→r18
84: r3/15+r14-r18→r19
85: r3/15+r14+r18→r20
86: if r20>24;r20-24→r20
87: fmt "CALCULATE INSOLATION CLASS NUMBER"
88: 0→r1
89: if r16>60;4→r1;gto "K1100"
90: if r16>35;3→r1;gto "K1100"
91: if r16>15;2→r1;gto "K1100"
92: if r16<=0;gto "K1300"
93: 1→r1
94: "K1100":
95: fmt "CALCULATE NET RADIATION INDEX FOR DAYTIME."
96: 0→r2
97: if B<50;r1→r2;gto "K1200"
98: if A<2133.6042;r1-2→r2;gto "K1200"
99: if A<4876.8096;r1-2→r3;gto "K1200"
100: if B=100;r1-1→r2
*22787
```

```
101: "K1200":
102: if r2=0;r1→r2
103: if r2<1;1→r2
104: r2→r0;gto "K1400"
105: "K1300":
106: fmt "CALCULATE NET RADIATION INDEX FOR NIGHTTIME."
107: if B<40;-2→r0;gto "K1400"
108: -1→r0
109: "K1400":
110: fmt "CALCULATE PASQUILL STABILITY CATEGORY."
111: 0→r4;0→r5
112: if r0=4;1→r4
113: if r0=3;2→r4
114: if r0=2;3→r4
115: if r0=1;4→r4
116: if r0=0;5→r4
117: if r0=-1;6→r4
118: if r0=-2;7→r4
119: if G<2;1→r5
120: if G<4;2→r5
121: if G<4;2→r5;gto "K1500"
122: if G<6;3→r5;gto "K1500"
123: if G<7;4→r5;gto "K1500"
124: if G<8;5→r5;gto "K1500"
125: if G<10;6→r5;gto "K1500"
126: if G<11;7→r5;gto "K1500"
127: if G<12;8→r5;gto "K1500"
128: 9→r5
129: "K1500":
130: A[r4,r5]→H
131: fmt "CALCULATE MIXING DEPTH HEIGHT."
132: (6-H)*121*(D-E)/6+H*.087*(G+.5)/(12*8.237e-5*5.809)→P
133: fmt "CALCULATE RELATIVE HUMIDITY."
134: if D>0;gto "K1600"
135: 9.5→r0;265.5→r1
136: gto "K1700"
137: "K1600":
138: 7.5→r0;237.3→r1
139: "K1700":
140: if E>0;gto "K1800"
141: 9.5→r2;265.5→r3
142: gto "K1900"
143: "K1800":
144: 7.5→r2;237.3→r3
145: "K1900":
146: 6.11*10^(r0*D/(r1+D))→r4
147: 6.11*10^(r2*E/(r3+E))→r5
148: r5/r4*100→Q
149: fmt "     METEOROLOGICAL CALCULATIONS:";wrt 701
150: fmt " ";wrt 701
*22910
```

```
151: fmt "        PASQUILL STABILITY CATEGORY = ",5x,cl
152: wrt 701,B$[H,H]
153: fmt "        RELATIVE HUMIDITY                = ",f6.2
154: wrt 701,Q
155: if E$[1,3]="YES";gto "K2000"
156: fmt /;wrt 701
157: fmt "    ATMOSPHERIC OPTICS AND SMOKE CONCENTRATION CALCULATIONS:"
158: wrt 701
159: "K2000":
160: fmt " ";wrt 701
161: ln(C)→r0
162: r0*r0→r1
163: r1*r0→r2
164: 1.5551-.9811*r0-.0197*r1+.0041*r2→F[1]
165: exp(F[1])→F[1]
166: 1.5551-.9811*r0-.0197*r1+.0041*r2→F[2]
167: exp(F[2])→F[2]
168: 1.4491-1.0044*r0-.012*r1+.0032*r2→F[3]
169: exp(F[3])→F[3]
170: 1.2394-1.0436*r0+.0099*r1-.0016*r2→F[4]
171: exp(F[4])→F[4]
172: 1.5176-1.7147*r0+.0001*r1+.0428*r2→F[5]
173: exp(F[5])→F[5]
174: 1.3306-.3825*r0-.0753*r1+.0129*r2→G[1]
175: exp(G[1])→G[1]
176: 1.4098-.9365*r0-.014*r1+2.3e-3*r2→G[2]
177: exp(G[2])→G[2]
178: 1.5497-.8696*r0-.1084*r1+.0231*r2→G[3]
179: exp(G[3])→G[3]
180: 1.5556-.9013*r0-.0773*r1+.0173*r2→G[4]
181: exp(G[4])→G[4]
182: 1.5928-.9396*r0-.0627*r1+.0168*r2→G[5]
183: exp(G[5])→G[5]
184: ent "SLANT RANGE TO TARGET - METERS",r20
185: ent "ANGLE OF SIGHT TO TARGET - DEG",r6
186: if E$[1,3]="YES";gto "K2100"
187: fmt"         SLANT RANGE TO TARGET              - METERS = ",f8.2
188: wrt 701,r20
189: fmt "         ANGLE OF SIGHT TO TARGET          - DEG    = ",3x,f5.2
190: wrt 701,r6
191: "K2100":
192: r20/1000→r20
193: if r6<0;-r6→r6
194: sin(r6)→r6
195: 0→r8
196: if r6=0;gto "K2200"
197: 1/r6→r8
198: "K2200":
199: fmt "CALCULATE PRECIPITABLE WATER."
200: .4477+.0328*E+1.2e-3*E^2+1.84e-5*E^3→r11
*28876
```

```
201: if E$[1,3]="YES";gto "K2300"
202: fmt " ";wrt 701
203: fmt "        PERCIPITABLE WATER                    - CM/KM   = ",4x,f4.2
204: wrt 701,r11
205: "K2300":
206: fmt "CALCULATE AMOUNT OF WATER VAPOR IN PATH."
207: r20→r0;0→r1;r0→r2;.5*(r1+r2)→r3
208: r2-r1→r4;.2886751*r4→r5
209: .5*r4*('FNA'(r3+r5)+'FNA'(r3-r5))→r9
210: r11*r9→r10
211: if E$[1,3]="YES";gto "K2400"
212: fmt "        AMOUNT OF WATER VAPOR IN PATH   - CM      = ",4x,f4.2
213: wrt 701,r10
214: "K2400":
215: fmt "CALCULATE TRANSMITTANCE FOR 0.55,1.06,2.3,3.8,10.6 MICROMETERS."
216: 1→M;17→N
217: for I=1 to 5
218: if E$[1,3]="YES";gto "K2500"
219: fmt " ";wrt 701
220: fmt 4x,c17;wrt 701,C$[M,N]
221: "K2500":
222: N+17→N;M+17→M
223: fmt "CALCULATE TRANSMITTANCE OWING TO ABSORPTION BY WATER VAPOR."
224: if I=5;exp(-.0681*r11)→B[I,1];gto "K2600"
225: D[I]*√(r10*π)/2→r0;0→r1;r0→r2
226: .5*(r1+r2)→r3
227: r2-r1→r4
228: .2886751*r4→r5
229: .5*r4*('FNB'(r3+r5)+'FNB'(r3-r5))→r12
230: 2/√π*r12→B[I,1]
231: 1-B[I,1]→B[I,1]
232: "K2600":
233: if E$[1,3]="YES";gto "K2700"
234: fmt " ";wrt 701
235: fmt "        TRANSMITTANCE OWING TO ATTENUATION BY:  WATER VAPOR = ",f5.2
236: wrt 701,B[I,1]
237: "K2700":
238: fmt "CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY HAZE AND FOG."
239: if D$[1,3]="YES";1→B[I,2];gto "K2900"
240: if C>=E[I];gto "K2800"
241: r8→r0;0→r1;r0→r2
242: .5*(r1+r2)→r3
243: r2-r1→r4
244: .2886751*r4→r5
245: .5*r4*('FNC'(r3+r5)+'FNC'(r3-r5))→r13
246: exp(-F[I]*r13)→r14
247: r20-r8→r0;r8→r1;r8+r0→r2
248: .5*(r1+r2)→r3
249: r2-r1→r4
250: .2886751*r4→r5
*26845
```

```
251: .5*r4*('FND'(r3+r5)+'FND'(r3-r5))→r15
252: exp(-.128*r15)→r16
253: r14*r16→B[I,2];gto "K2900"
254: "K2800":
255: r20→r0;0→r1;r0→r2;.5*(r1+r2)→r3
256: r2-r1→r4;.2886751*r4→r5
257: .5*r4*('FND'(r3+r5)+'FND'(r3-r5))→r17
258: exp(-F[I]*r17)→B[I,2]
259: "K2900":
260: if E$[1,3]="YES";gto "K3000"
261: fmt "                                        HAZE/FOG     = ",f5.2
262: wrt 701,B[I,2]
263: "K3000":
264: fmt "CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY RAIN."
265: if D$[1,2]="NO";1→B[I,3];gto "K3100"
266: if C>20;1→B[I,3];gto "K3100"
267: exp(-r20*G[I])→B[I,3]
268: "K3100":
269: if E$[1,3]="YES";gto "K3200"
270: fmt "                                        RAIN         = ",f5.2
271: wrt 701,B[I,3]
272: "K3200":
273: fmt "CALCULATE TRANSMITTANCE OWING TO ATTENUATION BY SMOKE."
274: .02/(B[I,1]*B[I,2]*B[I,3])→B[I,4]
275: if B[I,4]>1;1→B[I,4]
276: if E$[1,3]="YES";gto "K3300"
277: fmt "                                        SMOKE        = ",f5.2
278: wrt 701,B[I,4]
279: "K3300":
280: fmt "CALCULATE SMOKE CONCENTRATION."
281: if B[I,4]#1;gto "K3400"
282: for J=1 to 4;0→C[I,J]
283: next J;gto "K3500"
284: "K3400":
285: ln(B[I,4])→r18
286: r18*r18→r19
287: for K=1 to 4
288: H[1,K,I]+H[2,K,I]*r18+H[3,K,I]*r19→C[I,K]
289: next K
290: "K3500":
291: if E$[1,3]="YES";gto "K3600"
292: fmt " ";wrt 701
293: fmt "     SMOKE CONCENTRATION:  FOG OIL - GM/SQ M = ",f5.2
294: wrt 701,C[I,1]
295: fmt "                           HC      - GM/SQ M = ",f5.2
296: wrt 701,C[I,2]
297: fmt "                           FS      - GM/SQ M = ",f5.2
298: wrt 701,C[I,3]
299: fmt "                           WP      - GM/SQ M = ",f5.2
300: wrt 701,C[I,4]
*27168
```

```
301: "K3600":
302: next I
303: if E$[1,3]="YES";gto "K4000"
304: fmt /;wrt 701
305: fmt "     ATMOSPHERIC DIFFUSION SOURCE STRENGTH CALCULATIONS:";wrt 701
306: fmt " ";wrt 701
307: "K4000":
308: ent "TOTAL DISTANCE TO BE SMOKED - M",R
309: ent "RELEASE HEIGHT OF SMOKE SOURCE",r0
310: ent "MEAN HEIGHT OF TARGET - METERS",r1
311: ent "DIRECTION OF LINE OF SIGHT - DEG",r2
312: if E$[1,3]="YES";gto "K4050"
313: fmt "          TOTAL DISTANCE TO BE SMOKED            - METERS = ",f8.2
314: wrt 701,R
315: fmt "          RELEASE HEIGHT OF SMOKE SOURCE (AGL) - METERS = ",2x,f6.2
316: wrt 701,r0
317: fmt "          MEAN HEIGHT OF TARGET                - METERS = ",2x,f6.2
318: wrt 701,r1
319: fmt "          DIRECTION OF LINE OF SIGHT TO TARGET - DEG    = ",2x,f6.2
320: wrt 701,r2
321: "K4050":
322: fmt "DIFFUSION CALCULATIONS FOR CONTINUOUS SOURCE."
323: -1.24+1.19*log(Y)→r3
324: 10^r3→Z
325: ln(Z)→r8;ln(Z)^2→r9;ln(Z)^3→r10
326: ln(Z)^4→r11;ln(Z)^5→r12
327: .444685869+.294049265*r8-.237213914*r9→r13
328: .155349504*r10-.032015723*r11+2.15168e-3*r12→r14
329: r13+r14→r4
330: exp(r4)→r4
331: -1.298283909-1.006186784*r8+1.485094886*r9→r13
332: -.774136725*r10+.156559355*r11-.010823351*r12→r14
333: r13+r14→r5
334: exp(r5)-.225→r5
335: if Z>9.999999;gto "K4100"
336: 5.77267e-4+2.31943e-5*r8+3.71041e-5*r9→r13
337: -8.40602e-6*r10+1.3421e-7*r11+2.55131e-8*r12→r14
338: gto "K4175"
339: "K4100":
340: if Z>40;gto "K4150"
341: -11.56134901+2.148242814*r8-.156210817*r9→r13
342: 7.03582e-3*r10-1.47353e-4*r11+1.18256e-6*r12→r14
343: gto "K4175"
344: "K4150":
345: 1108.366588-103.5495836*r8+2.424499256*r9→r13
346: -.014584773*r10+4.34517e-5*r11-4.69556e-8*r12→r14
347: "K4175":
348: r13+r14→r6
349: .500775609+1.092614788*r8-1.573065836*r9→r13
350: .724276579*r10-.140820904*r11+9.61621e-3*r12→r14
*1824
```

```
351: r13+r14→r7
352: exp(r7)-1.2→r7
353: if Z>10;gto "K4200"
354: ln(r4*R^r5*1/(1+r6*R^r7))→r8
355: gto "K4225"
356: "K4200":
357: ln(r4*R^r5*(1+1/(r6*R^r7)))→r8
358: "K4225":
359: K[H,1]*R^K[H,2]/(1+K[H,3]*R^K[H,4])→r9
360: r8*r9→r10
361: J[H]*R^.9→r11
362: if E$[1,3]="YES";gto "K4250"
363: fmt " ";wrt 701
364: fmt "    CONTINUOUS SOURCE:";wrt 701
365: fmt " ";wrt 701
366: fmt "          SIGMA Y - METERS = ",f8.2;wrt 701,r11
367: fmt "          SIGMA Z - METERS = ",f8.2;wrt 701,r10
368: "K4250":
369: fmt "SMOKE SOURCE STRENGTH CALCULATIONS FOR CONTINUOUS SOURCE."
370: abs(r2-F)→r12
371: if G=0;1→G
372: G*.515→r13
373: 1→M;17→N
374: r10*r13*√π/√2*exp(-.5*((r1-r0)/r10)^2)→r14
375: √(3.3124/(6.76*sin(r12)*sin(r12)+.49*cos(r12)*cos(r12)))→r15
376: .9337+.0369*Q-7e-4*Q*Q+6.11e-6*Q*Q*Q→M[2]
377: 1.3775+.09868*Q-1.8e-3*Q*Q+1.56e-5*Q*Q*Q→M[3]
378: r14*r15→r14
379: r14/M[2]→r16
380: r14/M[3]→r17
381: for K=1 to 5
382: C[K,1]*r14→I[K,1]
383: C[K,2]*r16→I[K,2]
384: C[K,3]*r17→I[K,3]
385: if E$[1,3]="YES";gto "K4300"
386: fmt " ";wrt 701
387: fmt 4x,c17;wrt 701,C$[M,N]
388: "K4300":
389: N+17→N;M+17→M
390: if E$[1,3]="YES";gto "K4400"
391: fmt " ";wrt 701
392: fmt "          SOURCE STRENGTH:  FOG OIL - GMS/SEC = ",f8.2
393: wrt 701,I[K,1]
394: fmt "                           HC      - GMS/SEC = ",f8.2
395: wrt 701,I[K,2]
396: fmt "                           FS      - GMS/SEC = ",f8.2
397: wrt 701,I[K,3]
398: "K4400":
399: next K
400: fmt "DIFFUSION CALCULATIONS FOR QUASI-INSTANTANEOUS SOURCE."
*14590
```

```
401: 2/3*r11→r11
402: 2/3*r10→r10
403: if E$[1,3]="YES";gto "K4500"
404: fmt " ";wrt 701
405: fmt "     QUASI-INSTANTANEOUS SOURCE:";wrt 701
406: fmt " ";wrt 701
407: fmt "          SIGMA Y - METERS = ",f8.2;wrt 701,r11
408: fmt "          SIGMA Z - METERS = ",f8.2;wrt 701,r10
409: "K4500":
410: fmt "SMOKE SOURCE STRENGTH CALCULATIONS FOR QUASI-INSTANTANEOUS SOURCE."
411: 1→M;17→N
412: r11*r10*π/exp(-(r1*r1-r0*r0)/(2*r10*r10))→r14
413: 3.2469+.0774*Q-1.6e-3*Q*Q+1.73e-5*Q*Q*Q→M[4]
414: r14/M[4]*10→r14
415: for J=1 to 5
416: C[J,4]*r14→I[J,4]
417: if E$[1,3]="YES";gto "K4600"
418: fmt " ";wrt 701
419: fmt 4x,c17;wrt 701,C$[M,N]
420: "K4600":
421: N+17→N;M+17→M
422: if E$[1,3]="YES";gto "K4700"
423: fmt " ";wrt 701
424: fmt "          SOURCE STRENGTH:  WP - GMS/SEC = ",f8.2
425: wrt 701,I[J,4]
426: "K4700":
427: next J
428: fmt /;wrt 701
429: fmt "     MUNITION EXPENDITURES:";wrt 701
430: fmt " ";wrt 701
431: ent "TIME SMOKE REQUIRED - MINUTES",T
432: 1→I;17→J
433: for K=1 to 5
434: if K=1;gto "K5000"
435: if E$[1,3]="YES";gto "K5400"
436: "K5000":
437: if B[K,4]=1;gto "K5200"
438: fmt "CALCULATE NUMBER OF GUNS REQUIRED"
439: I[K,2]/S[1,1]→Q[1,1]
440: I[K,4]/S[1,2]→Q[1,2]
441: I[K,2]/S[2,1]→Q[2,1]
442: I[K,4]/S[2,2]→Q[2,2]
443: for L=1 to 2
444: for N=1 to 2
445: int(Q[L,N])→r0
446: Q[L,N]-r0→r1
447: if r1#0;r0+1→Q[L,N]
448: next N
449: next L
450: fmt "CALCULATE  TOTAL TIME FOR REPLENISHMENT."
*7095
```

```
451: for L=1 to 2
452: for N=1 to 2
453: T+T[L,N]-U[L,N]→X[L,N]
454: next N
455: next L
456: fmt "CALCULATE RATE OF FIRE."
457: for N=1 to 2
458: X[1,N]*V[N,H]+1→R[1,N]
459: X[2,N]*W[N,H]+1→R[2,N]
460: next N
461: fmt "CALCULATE TOTAL NUMBER OF ROUNDS REQUIRED."
462: for L=1 to 2
463: for N=1 to 2
464: Q[L,N]*R[L,N]→P[L,N]
465: int(P[L,N])→r2
466: P[L,N]-r2→r3
467: if r3#0;r2+1→P[L,N]
468: next N
469: next L
470: if E$[1,3]="YES";gto "K5100"
471: fmt 4x,c17;wrt 701,C$[I,J]
472: fmt " ";wrt 701
473: "K5100":
474: I+17→I;J+17→J
475: fmt "        VOLUME OF FIRE - HC SMOKESCREEN"
476: wrt 701
477: fmt "           SCREEN LENGTH   - METERS  = ",f3.2;wrt 701,R
478: fmt "           SCREEN DURATION - MINUTES = ",f8.2;wrt 701,T
479: fmt " ";wrt 701
480: fmt "                   GUNS      ROUNDS/MIN      TOTAL ROUNDS"
481: wrt 701
482: fmt "           105   ",f2.0,12x,f4.0,12x,f5.0
483: wrt 701,Q[1,1],V[1,H],P[1,1]
484: fmt "           155   ",f2.0,12x,f4.0,12x,f5.0
485: wrt 701,Q[2,1],W[1,H],P[2,1]
486: fmt /;wrt 701
487: fmt "        VOLUME OF FIRE - WP SMOKESCREEEN"
488: wrt 701
489: fmt "           SCREEN LENGTH   - METERS   = ",f8.2;wrt 701,R
490: fmt "           SCREEN DURATION - MINUTES  = ",f8.2;wrt 701,T
491: fmt " ";wrt 701
492: fmt "                   GUNS      ROUNDS/MIN      TOTAL ROUNDS"
493: wrt 701
494: fmt "           105   ",f2.0,12x,f4.0,12x,f5.0
495: wrt 701,Q[1,2],V[2,H],P[1,2]
496: fmt "           155   ",f2.0,12x,f4.0,12x,f5.0
497: wrt 701,Q[2,2],W[2,H],P[2,2]
498: gto "K5300"
499: "K5200":
500: I+16→I;J+16→J
*20059
```

```
501: fmt "     SMOKE NOT REQUIRED DUE TO ATMOSPHERIC CONDITIONS."
502: "K5300":fmt /;wrt 701
503: next K
504: "K5400":
505: fmt /;wrt 701
506: dsp "DONE"
507: end
508: "FNA":ret exp(-r6*p1/2)
509: "FNB":ret exp(-p1^2)
510: "FNC":ret exp(p1*r6*ln(.1/F[I]))
511: "FND":ret exp(-p1*r6/4.1)
*25712
```

SAMPLE CALCULATION

KWIK SMOKE PROGRAM

MET SITE:

ID		=	DMN
LATITUDE	- DEG	=	32.25
LONGITUDE	- DEG	=	107.72
ALTITUDE	- KM	=	1.32
JULIAN DATE	- DAY	=	322
ZULU TIME	- HOUR	=	23

METEOROLOGICAL INPUTS:

CEILING	- METERS	=	914.40
CLOUD COVER	- PERCENT	=	40.00
VISIBILITY	- KILOMETERS	=	8.05
PRECIPITATION		=	NO
TEMPERATURE	- DEG C	=	10.00
DEWPOINT	- DEG C	=	8.33
WIND DIRECTION	- DEG	=	180.00
WIND SPEED	- KNOTS	=	15.00
AVE ROUGHNESS ELEMENT	- CM	=	28.00

METEOROLOGICAL CALCULATIONS:

PASQUILL STABILITY CATEGORY	=	D
RELATIVE HUMIDITY	=	89.37

MUNITION EXPENDITURES:

VOLUME OF FIRE - HC SMOKESCREEN

SCREEN LENGTH	- METERS	=	200.00
SCREEN DURATION	- MINUTES	=	10.00

	GUNS	ROUNDS/MIN	TOTAL ROUNDS
105	1	2	17
155	1	1	8

VOLUME OF FIRE - WP SMOKESCREEN

SCREEN LENGTH	- METERS	=	200.00
SCREEN DURATION	- MINUTES	=	10.00

	GUNS	ROUNDS/MIN	TOTAL ROUNDS
105	1	4	43
155	1	2	22

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